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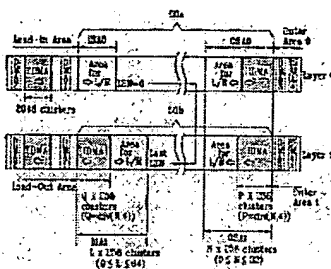
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WRITE-ONCE OPTICAL RECORDING MEDIUM AND DEFECT MANAGEMENT INFORMATION MANAGEMENT METHOD THEREOF**Publication number:** WO2004075180**Publication date:** 2004-09-02**Inventor:** PARK YONG CHEOL; KIM SUNG DAE**Applicant:** LG ELECTRONICS INC (KR)**Classification:****- international:** G11B7/00; G11B11/00; G11B20/18; H04L1/22;
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A write-once optical recording medium, a method for allocating a defect management area of the write-once optical recording medium, and a method for allocating a spare area of the write-once optical recording medium are provided. A method of managing defects on a write-once optical recording medium having at least one recording layer includes the steps of allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to said optical recording medium, respectively, recording defect management information on the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size; and using the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size is provided herein.



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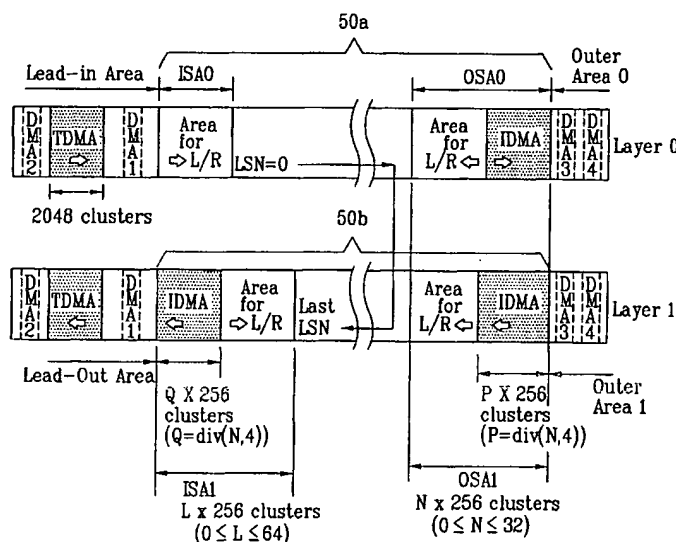
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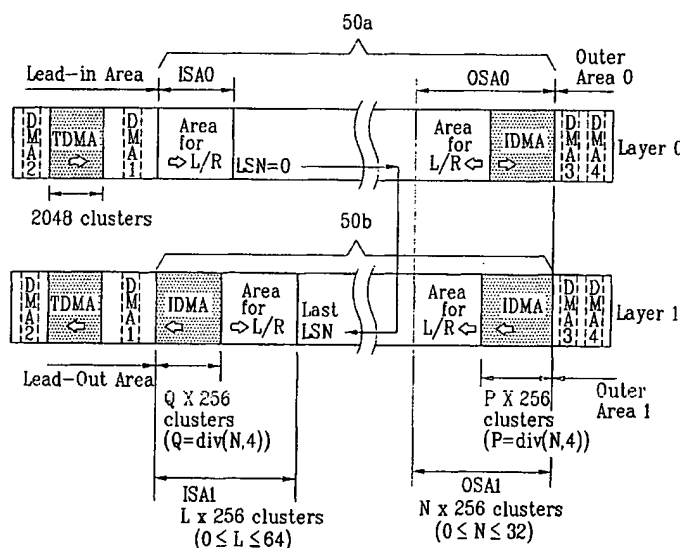
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**WRITE-ONCE OPTICAL RECORDING MEDIUM AND DEFECT
MANAGEMENT INFORMATION MANAGEMENT METHOD
THEREOF**

5 **Technical Field**

 The present invention relates to a write-once optical recording medium, a method and apparatus for managing defect management information thereof, and more particularly, to a method and device for allocating a temporary defect management area, a method for allocating a spare area for defect management, and a write-once optical recording medium on which the temporary defect management area and the spare area are allocated on a type of the optical recording medium such as a write-once Blu-ray disc.

15 **Background Art**

 Optical discs, which are a kind of optical recording media, can record a large amount of data, and are now being widely used. Currently, a kind of innovative high-density digital versatile disc (HD-DVD) such as blue ray disc (Blu-ray Disc) is under development. This kind of medium can record and store video data of high quality and audio data of high fidelity for a long time.

 The Blu-ray disc is a next generation optical recording solution that can store a larger amount of data than a conventional DVD.

 The Blu-ray disc generally employs a blue-violet laser having a wavelength of 405nm. This wavelength is shorter than a red laser used on a conventional DVD. The wavelength of the red laser is 650 nm. The Blu-ray disc has a thickness of 1.2 mm and a diameter of 12 cm, and includes a light

transmission layer having a thickness of about 0.1 mm. Therefore, the Blu-ray disc can store a larger amount of data than a conventional DVD.

An optical disc device for writing and reading data on the Blu-ray disc is shown in FIG. 1. It includes an optical pick-up 11 for writing and reading a signal on/from an optical disc 10, a video disc recorder (VDR) system 12 for processing the signal read out from the optical pick-up 11 into a replay signal, or for modulating and processing an externally inputted data stream into a record signal suitable for recording, and an encoder 13 for encoding an externally inputted analog signal and outputting the encoded analog signal to the VDR system 12.

A Blu-ray disc can be of a rewritable type, which is referred to herein as a Blu-ray Disc Rewritable (BD-RE). A BD-RE has a rewritable capability, which enables video and audio data to be written, erased, and rewritten thereon repeatedly. The BD-RE (shown in FIG. 2) is divided into a lead-in area (LIA), a data area and a lead-out area (LOA), and the front and the rear of the data area are allocated to have an inner spare area (ISA) and an outer spare area (OSA).

With the BD-RE configured in the manner described above, the VDR system 12 of the optical disc device shown in FIG.1 encodes and modulates externally inputted data into a signal suitable for recording, and records by cluster unit corresponding to error correction block unit. If a defective area occurs in the data area while recording data on the BD-RE, the data of one cluster unit recorded on the defective area is also recorded on the spare area (for example, the inner spare area on the BD-RE) according to a linear replacement operation. A series of linear replacement operations can be performed.

Accordingly, the VDR system 12 of the optical disc device records the data of the cluster unit recorded on the defective area onto the spare area, even if

the defective area occurs in the data area of the rewritable Blu-ray disc. When a playback operation is performed for the rewritable Blu-ray disc, the data recorded onto the spare area are read out and replayed so that a data recording error can be prevented.

5 Various standards related to the Blu-ray disc are under development.

In this respect, a second type of Blu-ray disc, on which data is not repeatedly rewritten (non-rewritable), but is written only once, is herein referred to as a Blu-ray Disc Write-Once (BD-WO).

The Write-once Blu-Ray disc is useful when it is not desirable to
10 repeatedly rewrite data. In a BD-WO, management of defective areas is needed.

Since data can be recorded on the BD-RE repeatedly (due to the characteristics of the BD-RE), the size of the defect management area (DMA) for the rewritable Blu-ray disc is relatively small (see DMA1-DMA4 in FIG.2). In contrast, since data is recorded on the write-once Blu-ray disc only one time,
15 the area required to manage the defective area for the BD-WO needs to be larger than the area required for the BD-RE. Accordingly, a sufficiently sized defect management area should be allocated for the BD-WO.

An effective defect management method for a BD-WO requires consistency and compatibility with standards that are applicable to the BD-RE,
20 including consistency and compatibility related to recording and replaying of management information in order to obtain more efficient, more stable and higher performance in recording and replaying information and data. Thus, an innovative method, apparatus and structure for both recording and management of defective areas and related information for the BD-WO are needed.

25

Disclosure of Invention

Accordingly, the present invention is directed to a write-once optical recording medium (BD-WO), a defect management information management method thereof, and an apparatus for implementing the method, that substantially obviate one or more problems due to limitations and disadvantages
5 of the background art.

Additional advantages, objects, and features of the invention will be set forth in part in the description which follows, and in part will become apparent to those having ordinary skill in the art upon examination of the following, or may be learned from practice of the invention. The objectives and other
10 advantages of the invention may be realized and attained by the structure particularly pointed out in the written description and claims hereof as well as the appended drawings.

To achieve these objects and other advantages and in accordance with the purpose of the invention, as embodied and broadly described herein, a method of
15 managing defects on a write-once optical recording medium having at least one recording layer, the method comprising the steps of allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to the optical recording medium, respectively, and recording defect management information
20 on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

In another aspect of the present invention, an apparatus for managing defects on a write-once optical recording medium, the apparatus comprising means for allocating at least one temporary defect management area having a
25 fixed size and at least one temporary defect management area having a variable size to the optical recording medium, respectively, and means for recording defect management information on the at least one temporary defect

management area having a fixed size and/or the at least one temporary defect management area having a variable size.

In another aspect of the present invention, a write-once optical recording medium having at least one recording layer comprises at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size, wherein defect management information is recorded on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

It is to be understood that both the foregoing general description and the following detailed description of the present invention are exemplary and explanatory and are intended to provide further explanation of the invention as claimed.

Brief Description of the Drawings

Further objects and advantages of the invention can be more fully understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 illustrates a schematic configuration of an optical disc device of the Background Art;

FIG. 2 illustrates a configuration of a recording area of a BD-RE;

FIG. 3 illustrates a schematic configuration of an optical disc device for a BD-WO of the present invention;

FIG. 4 illustrates a configuration of a recording area of an optical recording medium according to an embodiment of the present invention;

FIG. 5 illustrates a configuration of a recording area of an optical

recording medium according to another embodiment of the present invention;

FIG. 6 illustrates an example of a temporary or interim defect management area usage method of the present invention;

FIG. 7 illustrates another example of a temporary or interim defect management area usage method of the present invention;

FIG. 8 illustrates another example of a temporary or interim defect management information composition method of the present invention;

FIG. 9 illustrates another example of a temporary or interim defect management information composition method of the present invention;

FIG. 10 illustrates a configuration of TDDS and information contents according to an embodiment of the present invention; and

FIG. 11 is a table of comparison of DMA, TDMA and IDMA of the present invention.

Best mode for Carrying Out the Invention

Reference will now be made in detail to the preferred embodiments of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

Referring to FIG.3, an optical disc recording/reproducing device 20 for a Blu-ray write-once optical recording medium according to the present invention includes an optical pickup 22 for writing/reading data to/from an optical recording medium 21 such as a BD-WO, a pickup servo unit 23 for controlling the optical pickup 22 to maintain a distance between an objective lens in the optical pickup 22 and the optical recording medium 21 and for tracking a pertinent track, a data processor 24 for processing and providing input data to

the optical pickup 22, an interface 25 for exchanging data with an external host 30, a memory 27 for storing information regarding defect management, and a microcomputer 26 for controlling the above units. All of the components of the device 20 are operatively coupled. The host 30 is connected to the interface 25
5 of the device 20 for recording/reproducing data to/from the optical recording medium 21 for exchange of commands and data.

When an optical recording medium such as a BD-WO is loaded, the device 20 loads information regarding defect management, such as DMA (defect management area) information, TDMA (temporary defect management area)
10 information and so on, into the memory 26 or other suitable storage. During operation, the memory 27 is updated in accordance with a defect management operation. The present method can be also implemented using the device shown in FIG.1 or other suitable devices or systems.

FIG. 4 illustrates a configuration of a recording area of a BD-WO
15 according to the present invention. The BD-WO shown in FIG.4 has a structure of a single layer disc. Also, the BD-WO shown in FIG.4 includes a lead-in area, a data area and a lead-out area. A user data area is located in the data area. The lead-in and lead-out areas include final or permanent defect management areas (DMA1-DMA4). The arrows in each respective area are used
20 as examples of a data recording direction.

A temporary defect management area (TDMA) according to the present invention is provided in the lead-in area of the BD-WO. Here, the TDMA can be distinguished from the defect management areas (DMA1, DMA2, DMA3, DMA4). Particularly, the temporary defect management area (TDMA) is an
25 area of the BD-WO that is used to temporarily record and manage defect management information until the BD-WO is finalized. Afterward, the defect management information is recorded onto at least one of multiple defect

management areas, for example, DMA1-DMA4 on a recording layer shown in FIG. 4. The BD-WO is considered to be finalized, e.g., when recording of data onto a user data area of the BD-WO has been completed. The TDMA provided in the lead-in area has a fixed size, for example, 2048 clusters.

5 The data area of the BD-WO shown in FIG.4 includes the user data area, an inner spare area ISA0 and an outer spare area OSA0. The entire inner spare area ISA0 is used as an area for linear replacement, i.e., a replacement area for storing data assigned to a defective area of the user data area. No TDMA is allocated to the inner spare area ISA0. The outer spare area OSA0 includes an
10 interim defect management area (IDMA) as provided by an embodiment of the present invention. Here, the IDMA is distinguished from the TDMA having a fixed size in the lead-in area described above. In this regard, the IDMA is considered a temporary defect management area having a variable size. However, the TDMA and the IDMA may have the same contents despite the
15 difference between the terms and/or may differ from each other depending on a manner in which the TDMA and IDMA are used with respect to various manners, times and/or events in the actual recording process. This will be discussed in more detail when the methods of using the TDMA and IDMA are discussed.

20 In the single layer BD-WO shown in FIG. 4, a portion of the outer spare area OSA0 is used as the IDMA and a remaining portion of the outer spare area OSA0 is used as an area for linear replacement (replacement area). For example, the IDMA is allocated to a portion adjacent to the replacement area of the OSA0. The size of the IDMA is variably allocated depending on the size of
25 the spare area. Since the outer spare area (OSA0) has a variable size, the IDMA also has a variable size.

Here, the IDMA having a variable size is allocated to the data area,

depending on whether or not there is a determination made to allocate a spare area. If an outer spare area is to be allocated, the IDMA may be allocated in the manner described above. If an outer spare area is not allocated, only the TDMA having a fixed size is allocated (IDMA is not allocated). In such a case, the TDMA is used to manage defect management information. In another example, even though the spare area OSA0 exists, the IDMA may still not be allocated according to a choice of design. This means that the designer has a wide variety of design choices with respect to allocation of the IDMA. However, if the spare area (e.g., OSA0) is allocated, in one embodiment both are generally always allocated together, that is, if OSA0 is allocated, the IDMA is allocated also in the OSA0.

The size of the IDMA positioned at the outer track of the disc depends on the size of the spare area OSA0 (the size of OSA0 is variable). For example, if the size of the spare area OSA0 is $N \times 256$ ($0 \leq N \leq 64$) clusters, the size of the IDMA can be varied to $P \times 256$ clusters, where $P = N/4$. P and N may be integers. In other words, in the example set forth above, a method can be used (as an example) in which the size of the IDMA (having a variable size) is allocated by one-fourth the size of the outer spare area.

As an example, if $N = 64$, since the size of the outer spare area OSA0 is 16384 clusters and $P = N/4 = 16$, the size of the interim defect management area IDMA is 4096 clusters.

Similarly, the size of the IDMA positioned at an outer track area of the disc may have a size that is different from the example given above in that it is made to be variable depending on the size of the spare area OSA0. This is possible in a case which takes into consideration that when the area for linear replacement is reserved in the outer spare area OSA0, the size of the area for linear replacement, the size of the defect management area and the size of the

spare area OSA0 all depend on one another. In comparison, the size of the inner track area, especially the size of the TDMA positioned at the lead-in area, has a fixed value.

In the embodiment shown in FIG.4, it is readily apparent that the TDMA
5 is not positioned in the data area, but is positioned in the lead-in area. The interim defect management area IDMA is positioned in the outer spare area OSA0 and can be set to a size of '0'. In this case, the entire OSA0 would be used as a replacement area. In another case, the ISA0 and OSA0 can be allocated by a size of '0' if no defect management is to be performed. Nevertheless, since the
10 TDMA of the lead-in area is available, specific information can be recorded and managed using a temporary disc definition structure (TDDS), even though a temporary defect list (TDFL) is not managed. A further explanation of the method in which the TDFL and TDDS is recorded (and used herein) will be provided later.

15 According to the present embodiment, if a defective area (e.g., the user data area) is created or discovered when data are recorded in the BD-WO, the data recorded (or to be recorded) on the defective area is recorded on a predetermined area for linear replacement. A defective area may be created as a result of the recording process itself, or a defective area may be "discovered"
20 while recording. In the latter case, a discovered defective area is not the result of the current recording process. In case of the created defect, the corresponding defect management information is recorded on both the temporary and interim defect management areas TDMA and IDMA.

FIG. 5 shows an embodiment of the present invention, which illustrates
25 another configuration of a recording area of a BD-WO. The BD-WO shown in FIG. 5 has a structure of a dual layer disc. The BD-WO structure shown in FIG.5 includes a lead-in area, a data area 50a and an outer area (Outer Area 0)

on a first recording layer (Layer 0), and a lead-out area, a data area 50b and an outer area (Outer Area 1) on a second recording layer (Layer 1).

The arrows in each area are examples which indicate a data recording direction.

5 In the dual layer BD-WO shown, however, the temporary defect management area (TDMA) of the present invention is provided in both the lead-in area and the lead-out area. The data areas 50a, 50b include inner spare areas ISA0 and ISA1 and outer spare areas OSA0 and OSA1 as shown. Each of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 includes an
10 IDMA on each recording layer. In other words, an IDMA is allocated to each of the spare areas OSA0, OSA1 and ISA1, all having a variable size depending on the variable size of the spare area except for ISA0 (which may have a fixed size).

In this example, the TDMA provided in the lead-in area (first recording
15 layer) and the lead-out area (second recording layer) of the dual layer BD-WO shown in FIG.5 has a fixed size, for example, 2048 clusters.

All of the inner spare area ISA0 is used as an area for linear replacement. In other words, an IDMA for temporary defect management is not allocated to the inner spare area ISA0.

20 Portions of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 are used as the IDMA, and the remaining portions (or other portions) of the inner spare area ISA1 and the outer spare areas OSA0 and OSA1 are used as areas for linear replacement of a defective area. In one example, IDMA's are allocated to a portion in the spare areas, which is adjacent to an area for linear
25 replacement. The size of the IDMA(s) is allocated depending on the size of the spare areas ISA1, OSA0 and OSA1 (these spare areas have a variable size).

Here, the IDMA's having a variable size are allocated to the data area

depending on whether or not a determination is made to allocate the corresponding spare areas (spare area that corresponds to the particular IDMA). If the spare area is allocated, the IDMA's may be allocated as described above. If the spare areas are not allocated, only the TDMA's are allocated. Some or
 5 all of the lead-in area and/or the lead-out area may be used to store defect management information. As one example, if the size of the outer spare area OSA0, OSA1 is $N \times 256$ ($0 \leq N \leq 32$) clusters and the size of the inner spare area ISA1 is $L \times 256$ ($0 \leq L \leq 64$) clusters, then the size of the interim defect management areas in the OSA0 and OSA1 can be varied to $P \times 256$ clusters
 10 and the size of the interim defect management area in the ISA1 can be varied to $Q \times 256$ clusters, where P and Q are determined to be $P = N/4$ and $Q = L/4$. N and L may be integers. This method can be referred to as a method in which the size of the IDMA having a variable size is allocated by one-fourth the size of the corresponding outer or inner spare area OSA0, OSA1 or ISA1.

15 For example, if $N = 32$, since the size of the outer spare areas (OSA0 + OSA1) is 16384 clusters and $P = N/4 = 8$, the total size of the IDMA in the OSA0 and the IDMA in the OSA1 is 4096 clusters. If $L = 64$, since the size of the inner spare area ISA1 is 16384 clusters and $Q = L/4 = 16$, the size of IDMA in the ISA1 is 4096 clusters. Then the total size of all the interim defect
 20 management areas on the first and second recording layers is 8192 clusters.

Similarly, the size of the IDMA's is made to be variable depending on the size of the spare areas ISA1, OSA0 and OSA1, taking into account that when the area for linear replacement is designed to be in the spare area, the size of the area for linear replacement, the size of the defect management area and the size of the
 25 spare area all depend on one another. In comparison, the size of the inner track area (especially the TDMA positioned at the lead-in area and the lead-out area)

has a fixed value.

In the above embodiment having a dual layer BD-WO structure of the present invention, it is readily apparent that the TDMA is positioned in the lead-in area and also positioned in the lead-out area. The interim defect management areas IDMA positioned on the spare areas may have a size of '0' if all of the data area is used for user data recording. The spare areas may be allocated by a size of '0' if defect management is not performed. Nevertheless, since the TDMA of the lead-in area and the lead-out area remain available for use, specific information can be recorded and managed using a temporary disc definition structure (TDDS) although a temporary defect list (TDFL) may not be managed. These will be explained in more detail later, but meanwhile, an IDMA having a size of "0" is an indication that the TDFL is not managed.

Also according to the embodiment shown in FIG. 5, if a defective area is created during the actual recording of data in the BD-WO, the data to be recorded on the defective area is recorded on a predetermined area for linear replacement. In such a case, the associated defect management information may be recorded on both the temporary and interim defect management areas TDMA and IDMA in the OSA0, OSA1 or ISA1.

In general, allocation of an IDMA depends on whether or not a determination is made to allocate a spare area. Once a determination is made to allocate a spare area, the method of allocating an IDMA (employing the method of allocating a spare area and the method of managing a defect) will be applicable as described herein.

In addition to the discussion set forth above, there is also a case to be considered in which a spare area is not allocated in the dual layer BD-WO. Particularly, there is a case in which only the TDMA is used, and a case in which only the TDMA is used if only the inner spare area ISA0 is allocated. If the

inner spare area ISA0 and outer spare areas OSA0 and OSA1 are allocated, the IDMAS in the OSA0 and OSA1 are allocated. If only the inner spare areas ISA0 and ISA1 are allocated but the outer spare areas OSA0 and OSA1 are not allocated, the interim defect management area IDMA in the ISA1 can be
5 allocated. If all of the spare areas are allocated, the IDMA in the ISA1, OSA0 and OSA1 can all be allocated as described above.

FIG. 6 illustrates an example of a method of using temporary or interim defect management areas TDMA or IDMA in the single layer or dual layer BD-WO according to an embodiment of the present invention. In this method,
10 the TDMA shows both TDDS and TDFL. However, although not shown in the illustration, the IDMA can also include both TDDS and TDFL. The embodiment shown in FIG. 6 illustrates that the particular defect management information (TDDS and TDFL) is recorded in the TDMA before it is recorded in the IDMA.

15 A discussion of TDDS and TDFL will now be provided. In the present invention, TDDS refers to temporary disc definition structure and is distinguished from DDS (disc definition structure), in that TDDS is temporary. Similarly TDFL refers to a temporary defect list, and is distinguished from a DFL (defect list) in that TDDS is temporary. Herein, both the TDFL and TDDS
20 are included in the TDMA, and also both the TDFL and TDDS are included in the IDMA.

The temporary defect list (TDFL) contains (in part) a list of clusters that are determined to be defective during the use of the media. In relation thereto, TDDS specifies the format and status of the disc with relation to defect
25 management, and in general, provides overall management information. A format of the disc may include information regarding the specific layout of areas on the disc for managing defective areas, and status of a disc may include

various flags (explained below). The TDFL includes the addresses of the defective areas and the replacement areas on the BD-WO. TDDS and TDFL recorded in temporary defect management areas (for example, TDMA and IDMA), becomes permanent information (DDS and DFL) which is written in permanent defect management areas (for example DMA1-DMA4). For instance, when a disc is finalized, TDDS and TDFL are transferred and recorded in at least one of the DMAs. During the user data recording operation of the BD-WO, the TDDS and TDFL are updated periodically or at the same time and the updates are recorded in the TDMA(s) and/or the IDMA(s). The particular operation of these will become more apparent as the discussion thereof progresses.

In the embodiment shown in FIG.6, the TDMA is used first (before the IDMA is used) to record defect management information such as TDDS and TDFL. When the TDMA is full, the IDMA is used to record defect management information. However, in another variation, the IDMA is used first (before the TDMA). In this case, when the IDMA is full, the TDMA is used to record the defect management information. In such an instance, information providing notification of which area among the TDMA is full is indicated by a "full flag" of TDMA. The "full flag" indication is necessary because preferred embodiments disclosed herein require information indicating which area among a plurality of TDMAS and/or IDMAS is full. In one example, this TDMA full flag may be included in TDDS.

Accordingly, in the embodiment of FIG.6, the TDMA and IDMA, or the IDMA and TDMA are sequentially used to store defect management information. In further embodiments, the TDMA and IDMA are located in both lead-in areas and lead-out areas. The usage of a particular TDMA and IDMA depends on a variety of factors, examples of which will be provided in a discussion of

methods of using TDMA and IDMA.

It should be noted that the method of FIG. 6 and any other methods discussed herein (FIGS. 7-11) are applicable to the disc structures of FIGS. 4 and 5 and any other variations thereof discussed above. It should also be noted that
5 the present invention encompasses embodiments that include a plurality of TDMA's and IDMA's on each recording layer of the BD-WO.

FIG. 10 illustrates an example of a full flag indicating that the TDMA and/or IDMA is full (as recorded in the TDDS) according to an embodiment of the present invention. The TDDS, as mentioned above, includes overall
10 management information. In order to manage a defective area in the present invention, various full flags such as 'Spare Area full flag' and 'TDMA/IDMA full flag', and indicators such as 'the first PSN of latest TDFL' are used and included in the TDDS recorded in the TDMA(s) and/or IDMA(s). Particularly, a full flag provides information on whether a specific area is full and may be a 1-bit
15 indication corresponding to the specific area. In the embodiment shown, if the specific area is a particular TDMA or IDMA of the structure, and the value of the corresponding bit of the TDMA/IDMA full flag is "1", then the corresponding area (TDMA or IDMA) is regarded as being full or in a 'full' state. Accordingly, this TDMA/IDMA can no longer be used because the
20 TDMA/IDMA is full.

FIG. 10 also shows that the Spare Area full flag field includes the 8-bit structure indicated by the arrow extending therefrom. Similarly, the TDMA/IDMA full flag field (also in TDDS) includes the 8-bit structure indicated by the arrow extending therefrom. A number of bytes (size) and
25 corresponding sectors is also indicated in the example of a field in TDDS shown in FIG. 10.

As one example, the bits b3, b2, b1 and b0 of the Spare Area full flag are

use to indicate respectively whether or not the outer spare area OSA1, the inner spare area ISA1, the outer spare area OSAO, and the inner spare area ISAO are full. For instance, if the Spare Area full flag has a value of 00000011, this may indicate that the inner and outer spare areas ISAO and OSAO are full. If the
5 BD-WO is a single layer disc, then only the bits b1 and b0 may be used.

As another example, the bits b4-b0 of the TDMA/IDMA full flag are used to indicate respectively whether or not the IDMA in the OSA1, the IDMA in the ISA1, the IDMA in the OSAO, the TDMA in the lead-out area, and the TDMA in the lead-in area are full. For instance, if the TDMA/IDMA full flag
10 has a value of 00000010, then this may indicate that only the TDMA in the lead-out area is full. Obviously, other examples and assignment of bit values and positions are possible for these full flags.

In one embodiment, the size of the TDDS is fixed, e.g., 1 cluster, and the size of the TDFL is variable in recording the TDDS and the TDFL in FIG. 6.
15 The size of the TDFL of a dual layer BD-WO as shown in FIG. 5 can be changed from 1 cluster to 8 clusters. This size may be determined considering the capacity of an entire disc and the size of the spare area.

According to the method of using the TDMA/IDMA, if a defective area is created or discovered when data are recorded on a BD-WO, the data recorded or
20 to be recorded on the defective area of the BD-WO are recorded on a predetermined area (e.g., spare area) for linear replacement in the BD-WO.

FIG. 7 illustrates another example of a temporary or interim defect management area usage method of the present invention. In the method of using the temporary or interim defect management area shown in FIG. 7, the
25 TDMA and IDMA are used randomly without determining any usage order. The TDMA and IDMA full flags discussed in reference to FIG. 10 are equally applied herein.

If the TDMA/IDMA full flag indicates certain TDMA/IDMA is full, then a subsequent or TDMA/IDMA in the BD-WO is used. In a random case such as the case shown in FIG.7, no usage order is specified. If all the TDMA's and IDMA's are full, defects on the BD-WO cannot be managed any longer. When defects cannot be managed any longer, final information of TDDS and TDFL (i.e., the last updated TDDS and TDFL in the TDMA/IDMA) is transferred and recorded on at least one of the DMA's (DMA1-DMA4) to reflect the current disc status. Here, the same defect management information may be recorded in each of the DMA's so that if one DMA becomes defective, the important defect management information would not be lost. More discussion on recordation of final information on a DMA will be provided later.

According to the embodiment of FIG. 7, the data of a defective area are recorded on a predetermined area for linear replacement. The defect management information pertaining to this defective area and the replacement area is randomly recorded on the desired TDMA or IDMA. For example, the TDMA or IDMA nearest to the area where a defective area is located on the BD-WO is available for recording such defect management information. Therefore, as shown in FIG. 7, the TDMA or IDMA may be used variably, or as needed.

In another method of using a temporary defect management area in the embodiment of FIG. 7, a plurality of defect management areas are used variably depending upon a variety of conditions. In one example, the defect management information may be recorded only on an IDMA when using the BD-WO. The latest defect management information is recorded on a TDMA later when ejecting the BD-WO. In other words, the choice of an area in which to record defect management information is determined between the area to record defect management information when using the disc and the area to record defect management information when ejecting the disc.

In another example, when recording data on the BD-WO, the data recorded (or to be recorded) on the defective area are recorded on the predetermined area for linear replacement if a defective area is created or discovered during the process of recording data. The defect management information is recorded on an IDMA when using the disc. The same defect management information is again recorded on the TDMA when ejecting the disc. Since the TDMA is positioned in a management area (lead-in or lead-out) of an inner track of a disc, a system first obtains information from the management area when the disc is initially loaded. The TDMA includes the latest management information even in a situation in which a previous disc has been ejected.

As another method of using the disc, various objects are used for selecting one of a plurality of defect management areas. One method of using the disc is based on significance. For example, when the significance to update the defect management information is low, the IDMA may be used to record the defect management information therein. When the significance to update the defect management information is high, the TDMA may be used to record the defect management information therein. Here, the criterion used to determine the significance can be set variously. The frequency of refreshing (updating) defect management information can be made conditional, or based on a designer's choice. The time to eject a disc may also be designated as a significant time in recording defect management information. In such a case, the time a disc is in use is regarded to be less significant so that during this time, the defect management information may be recorded on the IDMA. The time to eject a disc may be regarded to be more significant so that during this time, the defect management information may be recorded on the TDMA. The methods that a designer decides to use are employed discretionally.

One of the criteria used to determine significance is an update interval (e.g., for updating the defect management information). In other words, if the time duration between the previous update time and the present update time is long, the present update information is regarded to be relatively significant. In this case, the defect management information can be recorded on a TDMA (instead of an IDMA) even though the disc is in use. Another criterion to determine significance is the number of defective areas created or discovered. If there are relatively many defective areas, since it is regarded that more reliability is required, defect management information may be recorded on a TDMA (instead of an IDMA) even though the disc is in use.

According to the objects of use, if defect management information is recorded on a TDMA according to significance, since the TDMA is positioned on the inner track, significant information can be rapidly and precisely obtained, beginning from the initial time of loading the disc.

FIGs. 8 and 9 illustrate examples of a temporary or interim defect management information composition method according to the embodiments of the present invention. In one embodiment, the present invention provides a method of composing and recording defect management information (TDDS and TDFL) on a TDMA or IDMA, wherein the TDDS and the TDFL are separated from each other. Another embodiment of the present invention provides a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL are integrated with each other. FIG. 8 shows the former case (separated) and FIG. 9 shows the latter case (integrated).

Particularly, FIG. 8 illustrates a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL are separated from each other. Each TDDS has a fixed size, e.g., 1

cluster, and the size of each TDFL is variable from, e.g., 1 cluster to 8 clusters.

FIG. 9 illustrates a method of composing and recording defect management information on a TDMA or IDMA wherein the TDDS and the TDFL of the TDMA or IDMA are integrated with each other. Defect management information is recorded in the form of TDFL + TDDS as shown in FIG. 9. That is, each time the defect management information is updated, both the latest TDFL and TDDS are recorded in the TDMA or IDMA. Since the size of the TDFL can be variable from 1 cluster to 8 clusters as described above, the size of the (TDFL + TDDS) is variable from 1 cluster to 8 clusters. The methods of FIGS. 8 and 9 are applicable to each of the disc structures and TDMA/IDMA usage methods discussed in this disclosure.

FIG. 11 is a table representing when a DMA, a TDMA and an IDMA are used and what information each of the DMA, TDMA and IDMA has according to the objects of use. For example, the defect management information is recorded on an IDMA when using the BD-WO. The defect management information is recorded on the TDMA when ejecting the BD-WO. The defect management information is recorded on the DMA when the DMA fill-in process may occur which happens, e.g., the BD-WO is to be finalized and data is not recorded any longer, when a spare area is full, or when a TDMA or IDMA is full and defects cannot be managed any longer. The full information (e.g., full flags) is recorded in TDDS as shown in FIG. 10. If the TDMA and the IDMA are not separated according to the objects of use, it is clear that times at which to record the defect management information on the TDMA and IDMA do not have to be distinguished from each other. The table in FIG. 11 representing when a DMA, a TDMA and an IDMA are used and what information each of the DMA, TDMA and IDMA has according to the objects of use apply to the structures discussed above, including the structures and methods shown in FIGS.

4-10, and the apparatus shown in FIG. 3.

Industrial applicability

5 In the present invention, the information to be recorded on the defective area is recorded on the area for linear replacement in the BD-WO. The defect management information is recorded on a plurality of temporary management areas provided separately on a predetermined area of the disc. The temporary management areas are divided into a temporary management area having a fixed
10 size and a temporary management area having a variable size depending on the spare area so that defect management information can be managed more effectively.

 It will be apparent to those skilled in the art that various modifications and variations can be made in the present invention. Thus, it is intended that the
15 present invention covers the modifications and variations of this invention provided they come within the scope of the appended claims and their equivalents.

What is claimed is:

1. A method of managing defects on a write-once optical recording medium having at least one recording layer, the method comprising the steps of:
5 allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to the optical recording medium, respectively; and
recording defect management information on the at least one temporary defect management area having a fixed size and/or the at least one temporary
10 defect management area having a variable size.
2. The method of managing of claim 1, wherein in the step of allocating, the optical recording medium has at least two recording layers, a first recording layer which includes a temporary defect management area having a fixed size
15 and a temporary defect management area having a variable size, and a second recording layer which includes a temporary defect management area having a fixed size and at least two temporary defect management areas having a variable size.
- 20 3. The method of managing of claim 1, wherein in the allocating step, the at least one temporary defect management area having a fixed size is allocated to at least one of a lead-in area and a lead-out area of the optical recording medium.
- 25 4. The method of managing of claim 3, wherein in the allocating step, the at least one temporary defect management area having a variable size is allocated to at least one spare of the optical recording medium.

5. The method of managing of claim 4, wherein the at least one spare area includes an inner spare area and an outer spare area on the optical recording medium.

5

6. The method of managing of claim 1, wherein the step of allocating further comprises:

allocating at least one inner spare area, a portion of which is used to replace a defective area;

10 allocating at least one outer spare area, a portion of which is used to replace a defective area; and

allocating a portion of the at least one outer or inner spare area as a temporary defect management area to manage defect management information.

15 7. The method of managing of claim 1, wherein in the step of allocating, the at least one temporary defect management area is allocated to a first outer spare area on the optical recording medium and has a size variable depending on a size of the entire first outer spare area.

20 8. The method of managing of claim 1, wherein in the step of allocating, the optical recording medium has at least two recording layers, a first recording layer which includes a first inner spare area, an entire area of which is used to replace a defective area and a first outer spare area having a variably allocated size, and a second recording layer which includes a second inner spare area and
25 a second outer spare area.

9. The method of managing of claim 4, wherein in the step of allocating,

if the at least one spare area is not allocated, the at least one temporary defect management area having a variable size is not allocated, but only the at least one temporary defect management area having a fixed size is allocated.

5 10. The method of managing of claim 4, wherein in the step of allocating, if the at least one spare area is allocated, the at least one temporary defect management area having a variable size is not allocated, but only the at least one temporary defect management area having a fixed size is allocated.

10 11. The method of managing of claim 1, wherein the optical recording medium is a write-once Blu-ray disc (BD-WO).

 12. The method of managing of claim 1, wherein in the step of recording, said defect management information includes at least one temporary defect list
15 (TDFL) and at least one temporary disc definition structure (TDDS).

 13. The method of managing of claim 12, wherein the size of the at least one temporary disc definition structure is fixed, and the size of the at least one temporary defect list is variable.

20

 14. The method of managing of claim 12, wherein the at least one temporary defect list and the at least one temporary disc definition structure are separated.

25 15. The method of managing of claim 12, wherein the at least one temporary defect list and the at least one temporary disc definition structure are integrated.

16. The method of managing of claim 1, wherein in the step of recording, the at least one temporary defect management area having a fixed size and the at least one temporary defect management areas having a variable size are used sequentially to record therein the defect management information.

17. The method of managing of claim 1, wherein in the step of recording, the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size are used randomly without a predetermined order to record therein the defect management information.

18. The method of managing of claim 1, wherein in the step of recording, the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size are used in an order depending on the significance given to the defect management information.

19. The method of managing of claim 1, wherein in the step of recording, the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size are used in an order which depends on a number of defective areas present on the optical recording medium.

20. The method of managing of claim 1, wherein in the step of recording, the defect management information is recorded on the at least one temporary defect management area having a fixed size and the at least one temporary defect

management area having a variable size depending on a time duration between a previous defect management information update time and a current defect management information update time.

5 21. The method of managing of claim 20, wherein if the time duration between the previous update time and the current update time exceeds a reference time duration, the defect management information is recorded on the at least one temporary defect management area having a fixed size.

10 22. The method managing of claim 1, wherein in the step of recording, the defect management information is recorded on the at least one temporary defect management area having a variable size when using the optical recording medium and on the at least one temporary defect management area having a fixed size when ejecting the optical recording medium.

15 23. The method of managing of claim 1, wherein, if a defective area is created when recording data, the data to be recorded is recorded on a predetermined area for linear replacement, and in the recording step, the defect management information pertaining to the defective area is recorded randomly in
20 either the at least one temporary defect management area having a fixed size or the at least one temporary defect management area having a variable size depending on which temporary defect management area is nearest to the created defective area.

25 24. The method of managing of claim 1, wherein the at least one temporary defect management area having a variable size is accessed first at an initial time of loading the optical recording medium.

25. The method of managing of claim 1, wherein in the recording step, the defect management information includes full indication information providing notification of which area among the temporary defect management areas is full.

26. The method of managing of claim 1, further comprising:
recording defect management information on a permanent defect management area of the optical recording medium when the optical recording medium is to be finalized.

27. The method of managing of claim 1, further comprising:
recording defect management information in a permanent management area of the optical recording medium when a spare area of the optical recording medium is full.

28. The method of managing of claim 1, further comprising:
recording defect management information on a permanent management area of the optical recording medium when the temporary defect management areas are full and defects cannot be managed any longer.

29. An apparatus for managing defects on a write-once optical recording medium, the apparatus comprising:
means for allocating at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size to the optical recording medium, respectively; and
means for recording defect management information on the at least one

temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

30. A write-once optical recording medium having at least one recording
5 layer, comprising at least one temporary defect management area having a fixed size and at least one temporary defect management area having a variable size, wherein defect management information is recorded on the at least one temporary defect management area having a fixed size and/or the at least one temporary defect management area having a variable size.

10

31. The optical recording medium of claim 30, wherein the optical recording medium comprises at least two recording layers, including:

a first recording layer, which includes a temporary defect management area having a fixed size and a temporary defect management area having a
15 variable size; and

a second recording layer which includes a temporary defect management area having a fixed size and at least two temporary defect management areas having a variable size.

20 32. The optical recording medium of claim 30, wherein the at least one temporary defect management area having a fixed size is located in at least one of a lead-in area and a lead-out area of the optical recording medium.

33. The optical recording medium of claim 32, wherein the at least one
25 temporary defect management area having a variable size is located in at least one spare area of the optical recording medium.

34. The optical recording medium of claim 33, wherein the at least one spare area includes an inner spare area and an outer spare area on the optical recording medium.

5 35. The optical recording medium of claim 30, further comprising:
 at least one inner spare area, a portion of which is used to replace a defective area; and
 at least one outer spare area, a portion of which is used to replace a defective area,
10 wherein a portion of the at least one outer or inner spare area is used as a temporary defect management area to manage defect management information.

 36. The optical recording medium of claim 30, wherein the at least one temporary defect management area having a variable size is located in a first
15 outer spare area on the optical recording medium and has a size variable depending on a size of the entire first outer spare area.

 37. The optical recording medium of claim 30, wherein said optical recording medium has at least two recording layers, said at least two recording
20 layers comprising:
 a first recording layer which includes a first inner spare area, an entire area of which is used to replace a defective area and a first outer spare area having a variably allocated size; and
 a second recording layer which includes a second inner spare area and a
25 second outer spare area.

 38. The optical recording medium of claim 30, wherein the optical

recording medium is a write-once Blu-ray disc (BD-WO).

39. The optical recording medium of claim 30, wherein said defect management information includes at least one temporary defect list (TDFL) and
5 at least one temporary disc definition structure (TDDS).

40. The optical recording medium of claim 39, wherein the size of the at least one temporary disc definition structure is fixed, and the size of the at least one temporary defect list is variable.

10

41. The optical recording medium of claim 39, wherein the at least one temporary defect list and the at least one temporary disc definition structure are separated.

15 42. The optical recording medium of claim 39, wherein the at least one temporary defect list and the at least one temporary disc definition structure are integrated.

43. The optical recording medium of claim 30, wherein the at least one
20 temporary defect management area having a fixed size and the at least one temporary defect management areas having a variable size are used sequentially to record therein the defect management information.

44. The optical recording medium area having a fixed size and the at least
25 one temporary defect management area having a variable size is used randomly without a predetermined order to record therein the defect management information.

45. The optical recording medium of claim 30, wherein the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size are used in an order
5 depending on the significance given to the defect management information.

46. The optical recording medium of claim 30, wherein the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size are used in an order
10 which depends on a number of defective areas present on the optical recording medium.

47. The optical recording medium of claim 30, wherein the defect management information is recorded on the at least one temporary defect management area having a fixed size and the at least one temporary defect management area having a variable size depending on a time duration between a previous defect management information update time and a current defect management information update time.
15

20 48. The optical recording medium of claim 47, wherein if the time duration between the previous update time and the current update time exceeds a reference time duration, the defect management information is recorded on the at least one temporary defect management area having a fixed size.

25 49. The optical recording medium of claim 30, wherein the defect management information is recorded on the at least one temporary defect management area having a variable size when using the optical recording

medium and on the at least one temporary defect management area having a fixed size when ejecting the optical recording medium.

50. The optical recording medium of claim 30, wherein, if a defective
5 area is created when recording data, the data to be recorded is recorded on a predetermined area for linear replacement, and in the recording step, the defect management information pertaining to the defective area is recorded randomly in either the at least one temporary defect management area having a fixed size or the at least one temporary defect management area having a variable size
10 depending on which temporary defect management area is nearest to the created defective area.

51. The optical recording medium of claim 30, wherein the at least one temporary defect management area having a variable size is accessed first at an
15 initial time of loading the optical recording medium.

52. The optical recording medium of claim 30, wherein the defect management information includes full indication information providing notification of which area among the temporary defect management areas is full.
20

53. The optical recording medium of claim 30, further comprising:
a permanent management area to record therein defect management information when the optical recording medium is to be finalized.

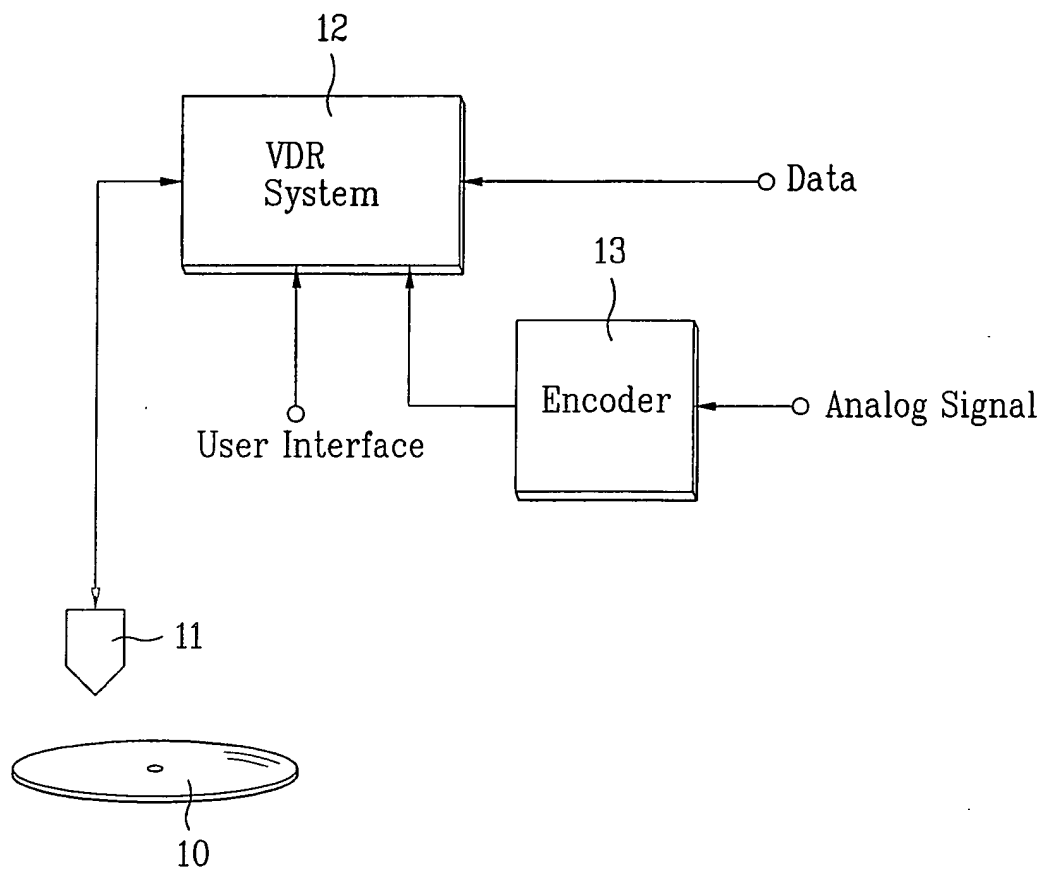
25 54. The optical recording medium of claim 30, further comprising:
a permanent management area to record therein defect management information when a spare area of the optical recording medium is full.

55. The optical recording medium of claim 30, further comprising:

a permanent management area to record therein defect management information when the temporary defect management areas are full and defects
5 cannot be managed any longer.

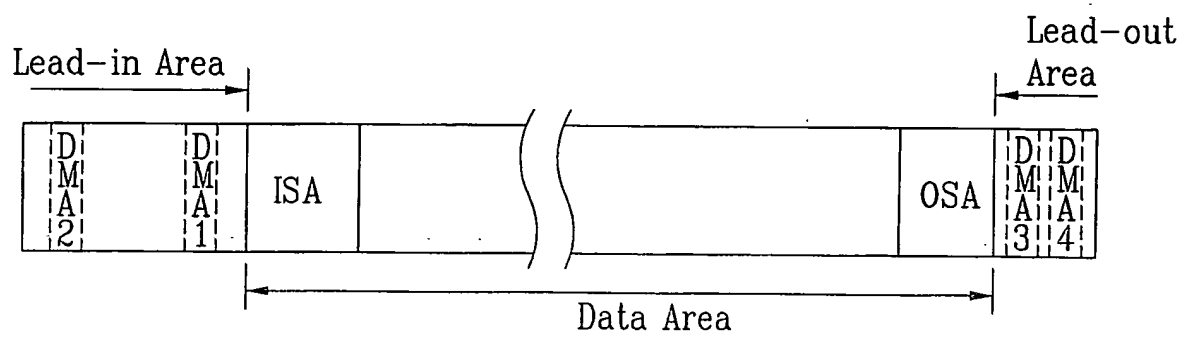
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FIG. 1
Background Art



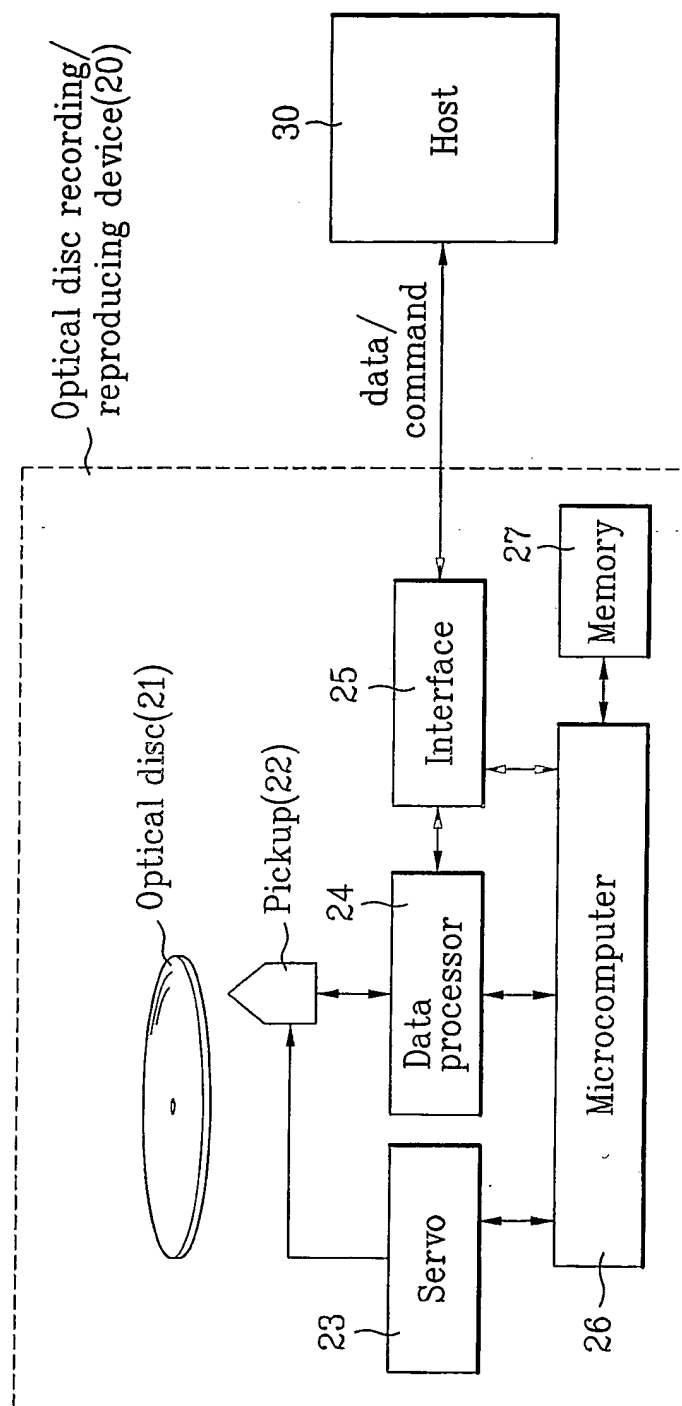
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FIG. 2
Background Art



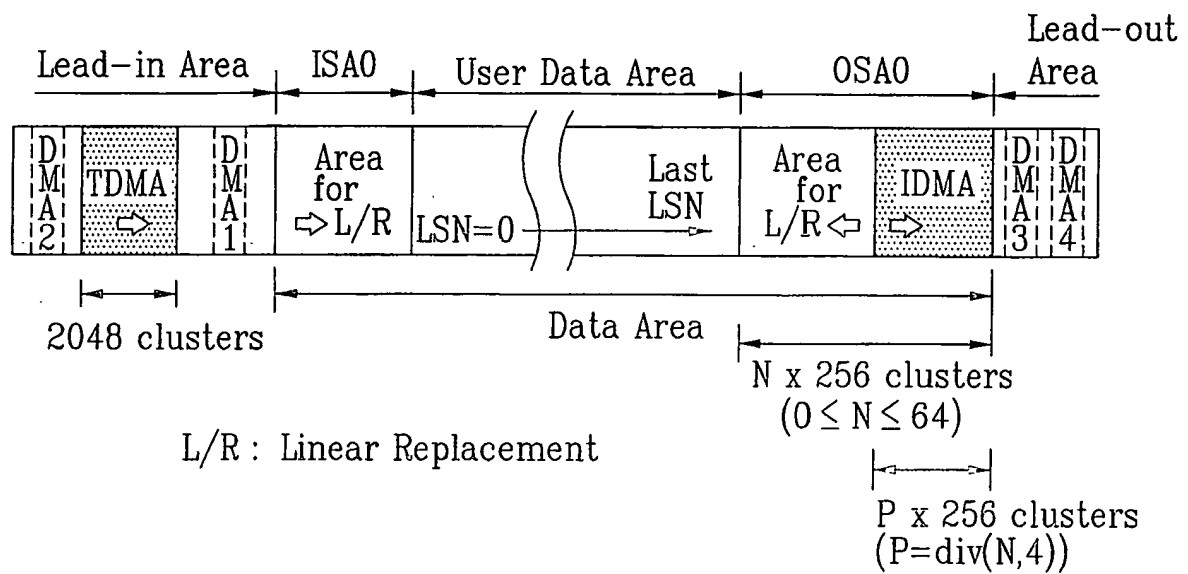
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FIG. 3



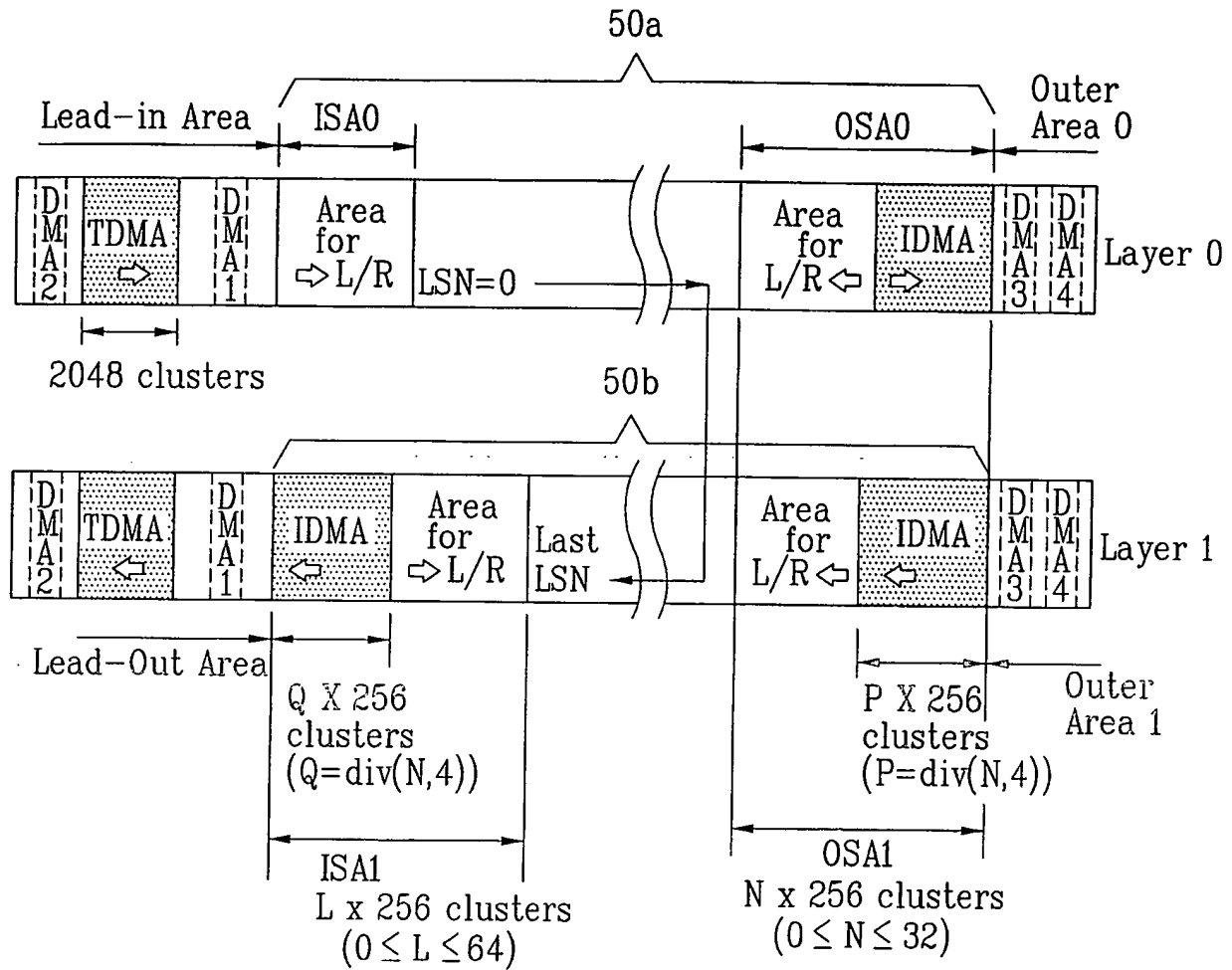
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FIG. 4



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FIG. 5



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FIG. 6

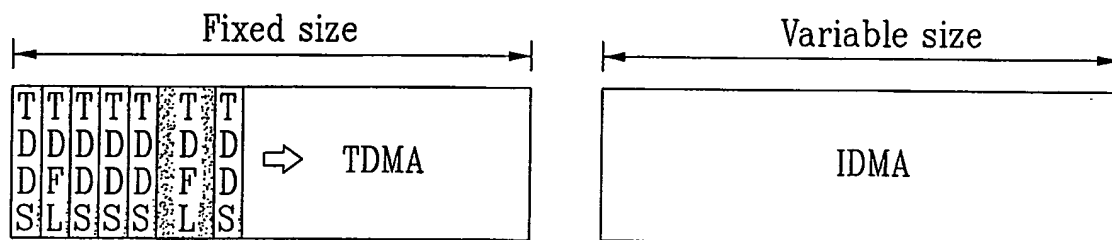
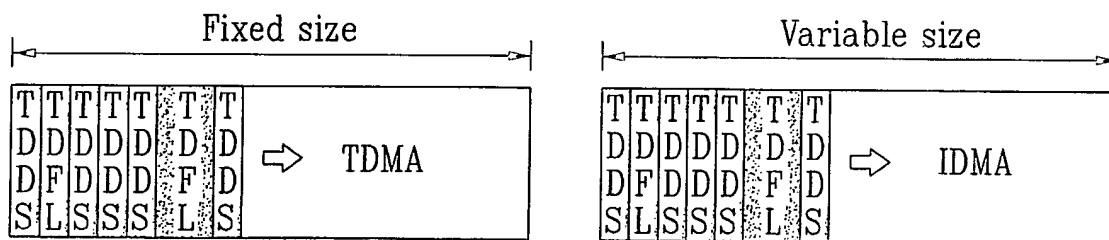


FIG. 7



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FIG. 8

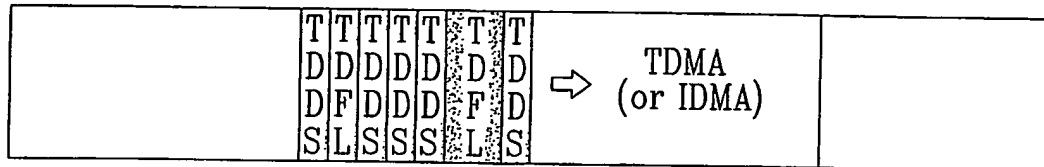
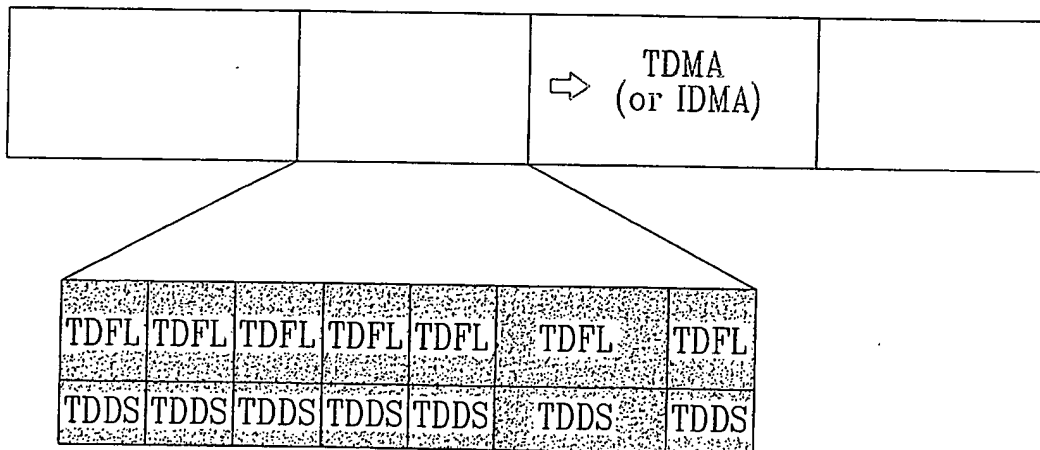
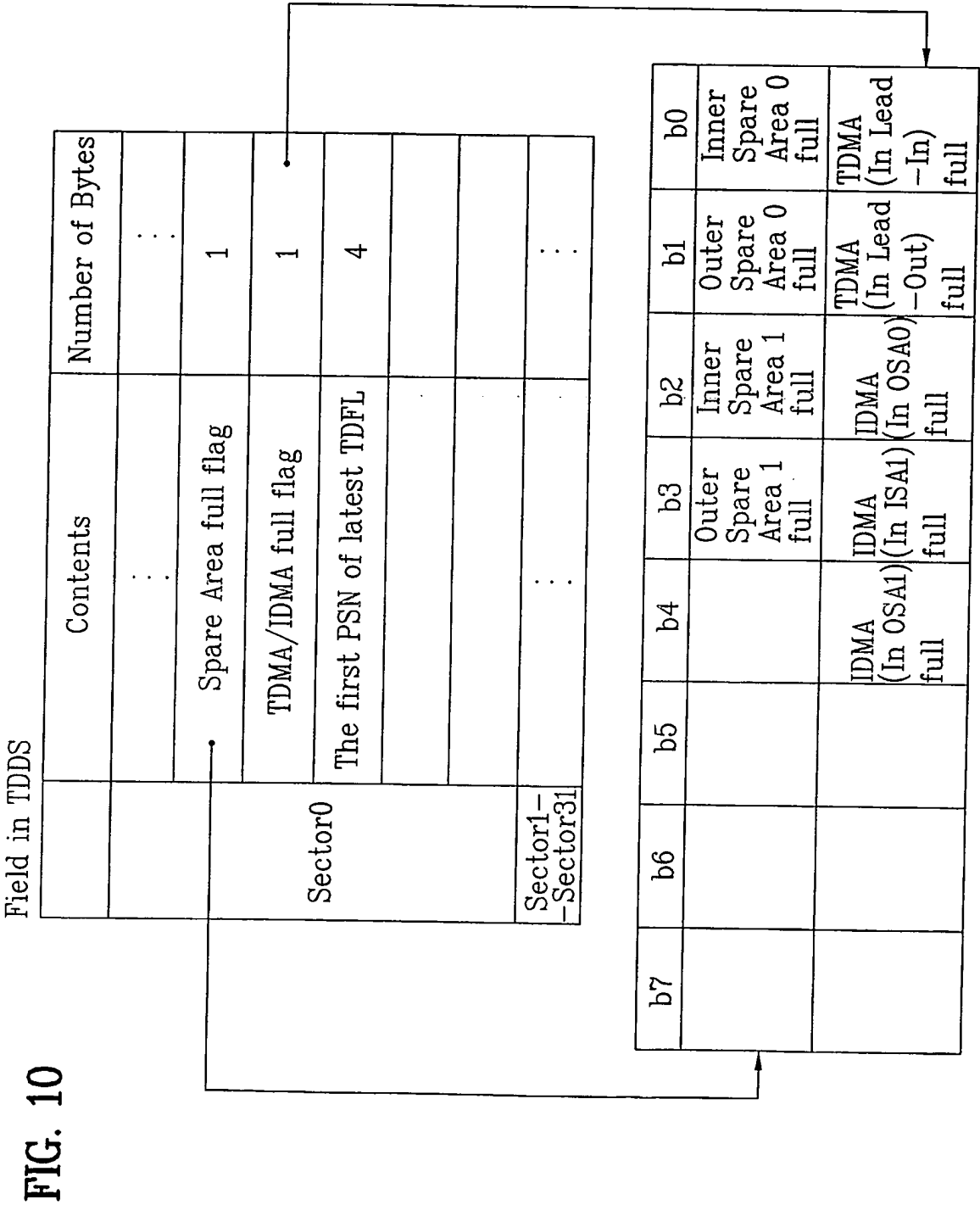


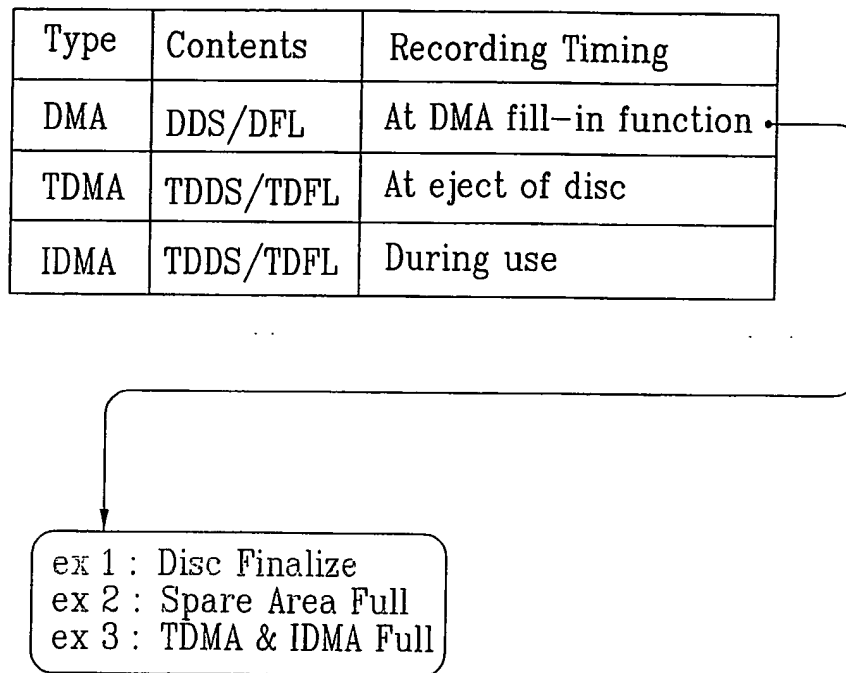
FIG. 9





9/9

FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR 03/02027-0

CLASSIFICATION OF SUBJECT MATTER

IPC⁷: G11B 7/00, G11B 11/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC⁷: G11B 7/00, 11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5805536 A (Gage et al.) 8 September 1989 (08.09.89)	1,29,30,44
A	EP 1148493 A2 (Samsung) 24 October 2001 (24.10.01)	1,29,30,44

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:

- „A“ document defining the general state of the art which is not considered to be of particular relevance
- „E“ earlier application or patent but published on or after the international filing date
- „L“ document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- „O“ document referring to an oral disclosure, use, exhibition or other means
- „P“ document published prior to the international filing date but later than the priority date claimed

- „T“ later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- „X“ document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- „Y“ document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- „&“ document member of the same patent family

Date of the actual completion of the international search
10 February 2004 (10.02.2004)Date of mailing of the international search report
11 March 2004 (11.03.2004)Name and mailing address of the ISA/AT
Austrian Patent Office
Dresdner Straße 87, A-1200 Vienna
Facsimile No. 1/53424/535Authorized officer
GRÖSSING G.
Telephone No. 1/53424/386

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR 03/02027-0

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
EP	A	1148493		ID A 29760	2001-10-11
				TW B 544660	2003-08-01
				KR A 2001090964	2001-10-22
				CA A 2342580	2001-10-08
				JP A 2002056631	2002-02-22
				BR A 0103628	2002-02-19
US	A	5805536	1998-09-08	none	

(12) UK Patent Application (19) GB (11) 2 356 735 (13) A

(43) Date of A Publication 30.05.2001

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Date Lodged 16.10.2000

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(51) INT CL⁷

G11B 20/18

(52) UK CL (Edition S)

G5R RB265 RB33

(56) Documents Cited

US 5237553 A

(58) Field of Search

UK CL (Edition S) G5R RB27 RB33

INT CL⁷ G11B 20/12 20/18

EPODOC; JAPIO; WPI

(74) Agent and/or Address for Service

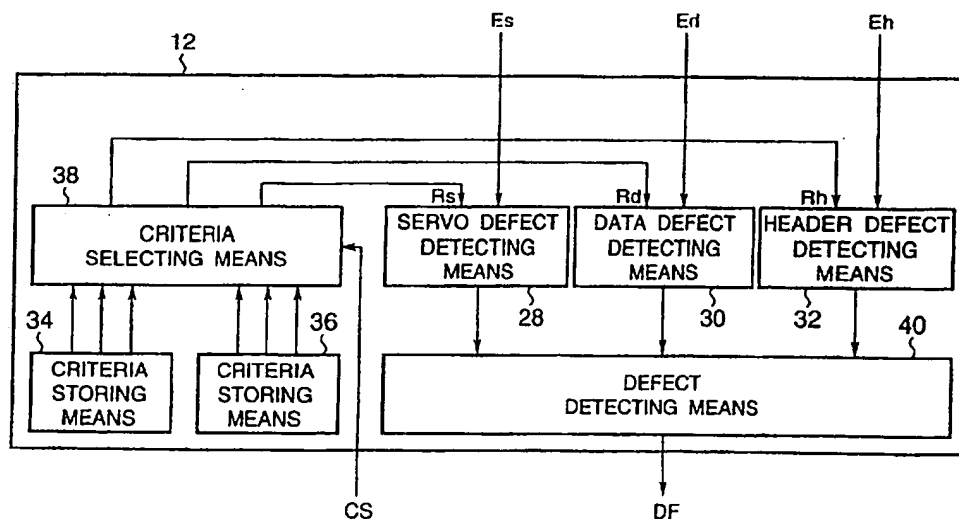
R.G.C.Jenkins & Co
26 Caxton Street, LONDON, SW1H 0RJ,
United Kingdom

(54) Abstract Title

Managing defects in an optical disk

(57) When optical disk defects are managed by using non-defective areas in place of defective areas, different criteria are used for detecting the defects, depending on the type of data recorded on the disk. For example, to avoid interruptions of real-time recording, less strict criteria are used when audio or video data is recorded than when computer data is recorded. The criteria themselves may also be recorded on the disk.

FIG.2



GB 2 356 735 A

FIG.1

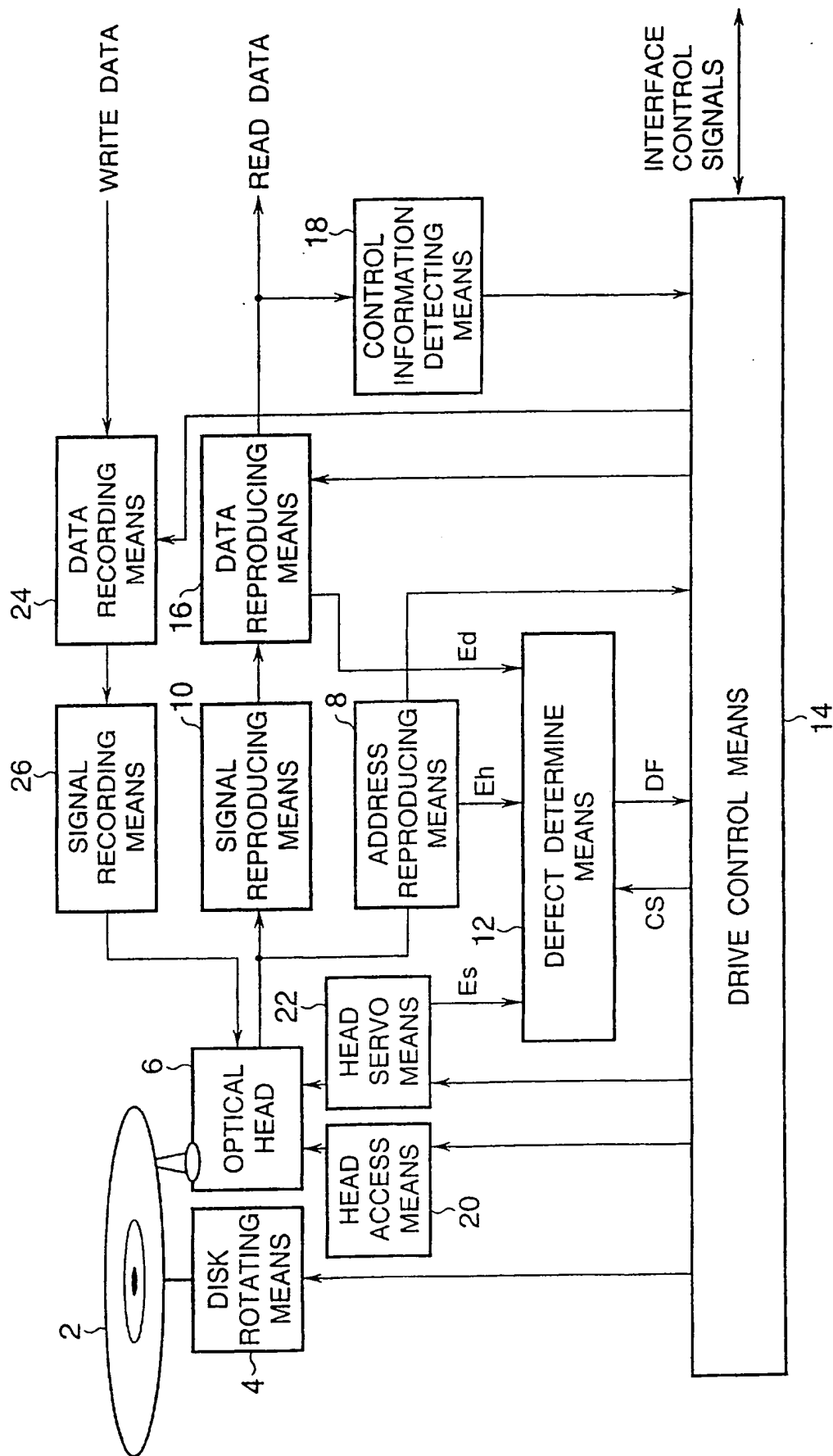


FIG.2

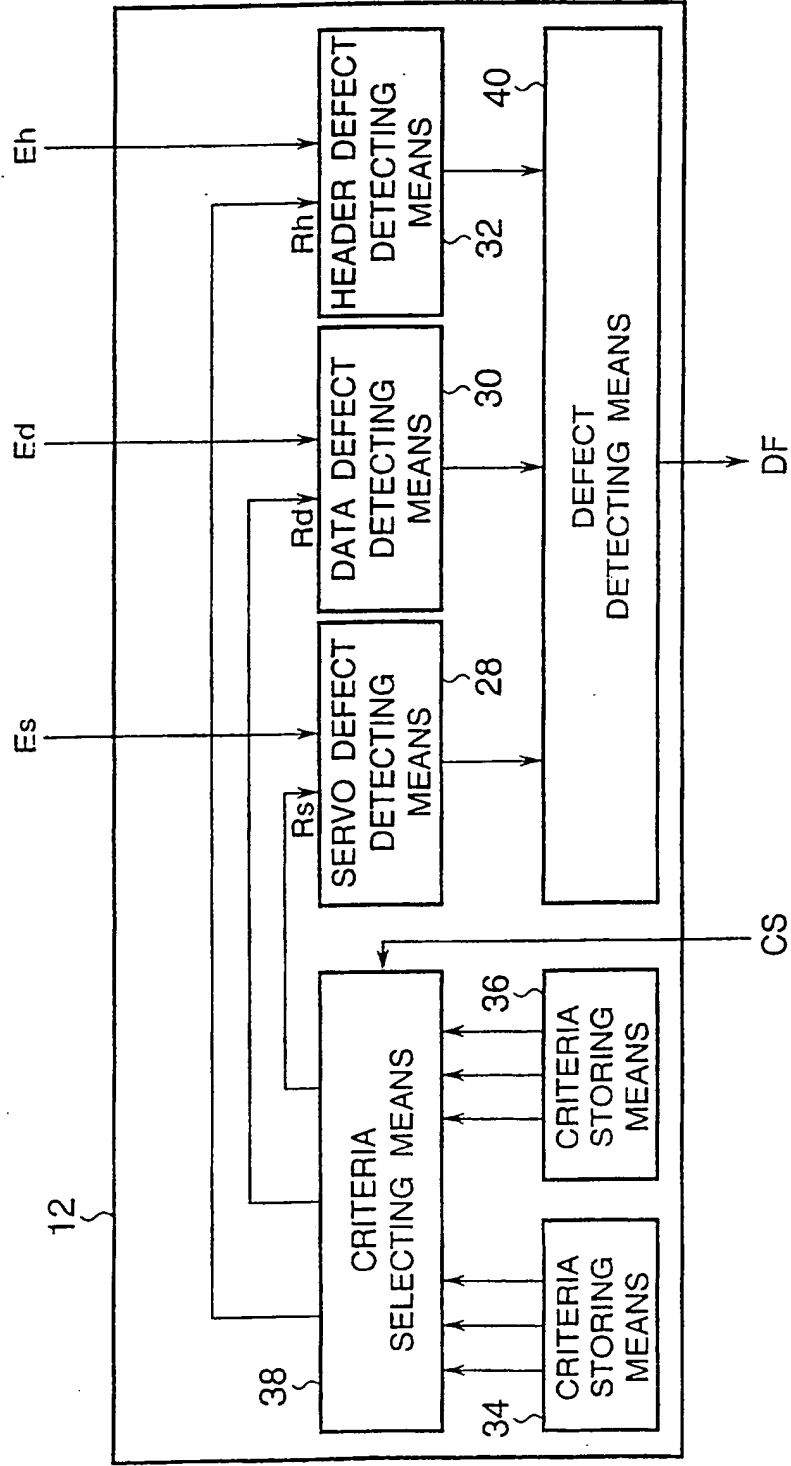


FIG.3A

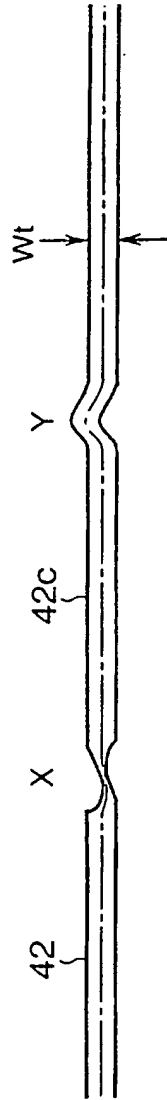


FIG.3B

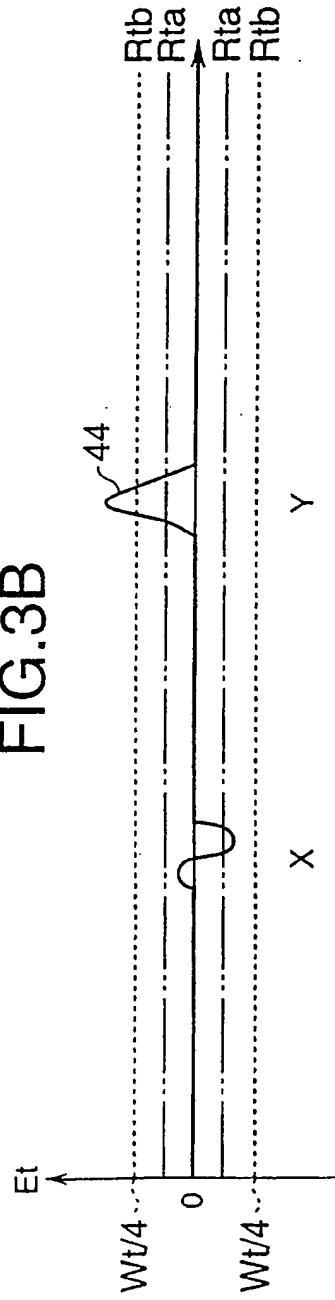


FIG. 4A

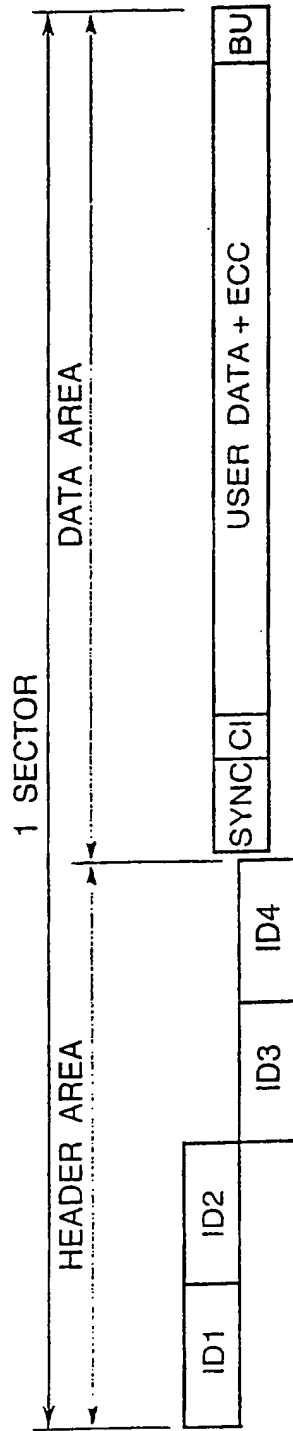


FIG. 4B

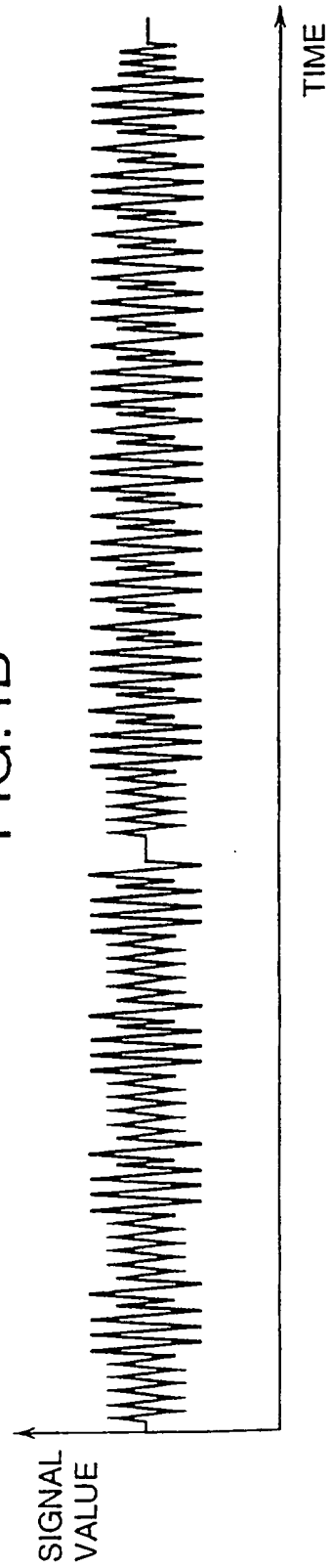


FIG.5

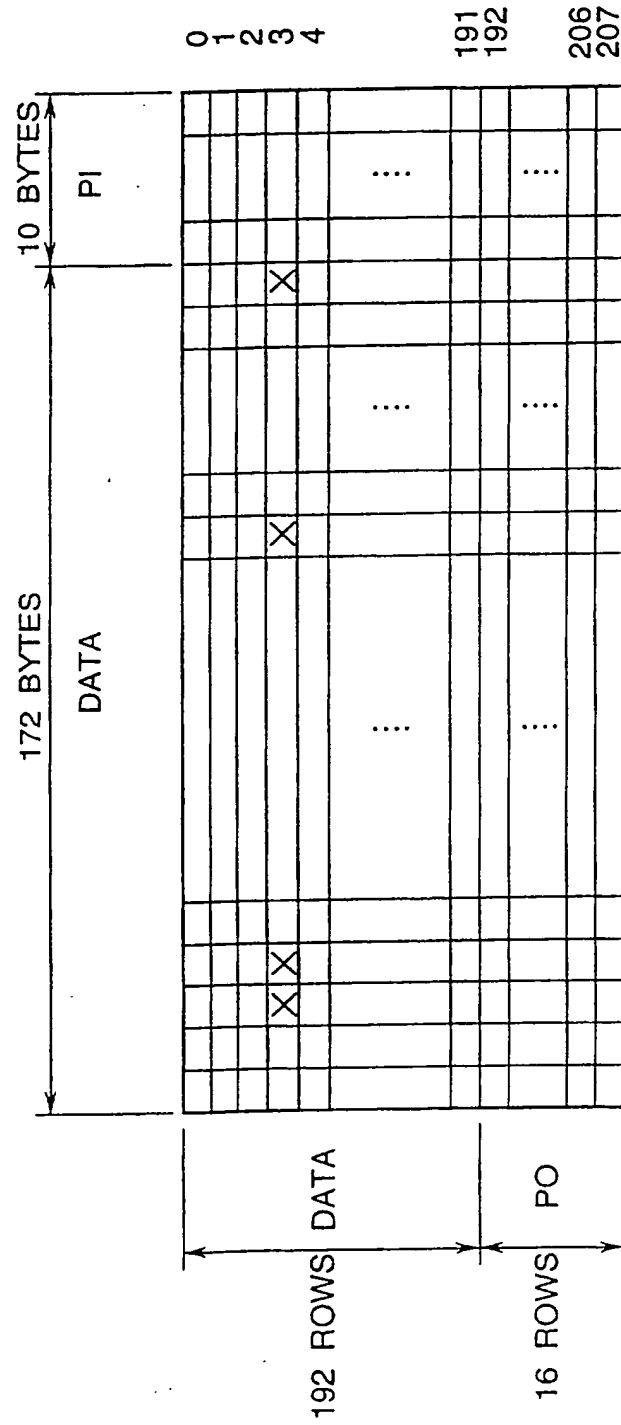


FIG.6

TYPE	CRITERIA A	CRITERIA B
SERVO DEFECT	TRACKING ERROR $\geq W/8$	TRACKING ERROR $\geq W/4$
HEADER DEFECT	AT LEAST 1 SECTOR WITH 3 OR MORE ERRONEOUS HEADERS	AT LEAST 2 SECTORS WITH 4 ERRONEOUS HEADERS EACH
DATA DEFECT	AT LEAST 8 ROWS WITH AT LEAST 4 ERRONEOUS BYTES EACH	AT LEAST 8 ROWS WITH AT LEAST 8 ERRONEOUS BYTES EACH

FIG.7

TYPE	CRITERIA A	CRITERIA C	CRITERIA B
SERVO DEFECT	TRACKING ERROR $\geq Wt/8$	TRACKING ERROR $\geq Wt/6$	TRACKING ERROR $\geq Wt/4$
HEADER DEFECT	AT LEAST 1 SECTOR WITH 3 OR MORE ERRONEOUS HEADERS	AT LEAST 1 SECTOR WITH 4 ERRONEOUS HEADERS	AT LEAST 2 SECTORS WITH 4 ERRONEOUS HEADERS
DATA DEFECT	AT LEAST 8 ROWS WITH AT LEAST 4 ERRONEOUS BYTES EACH	AT LEAST 8 ROWS WITH AT LEAST 4 ERRONEOUS BYTES EACH	AT LEAST 8 ROWS WITH AT LEAST 8 ERRONEOUS BYTES EACH

FIG. 8

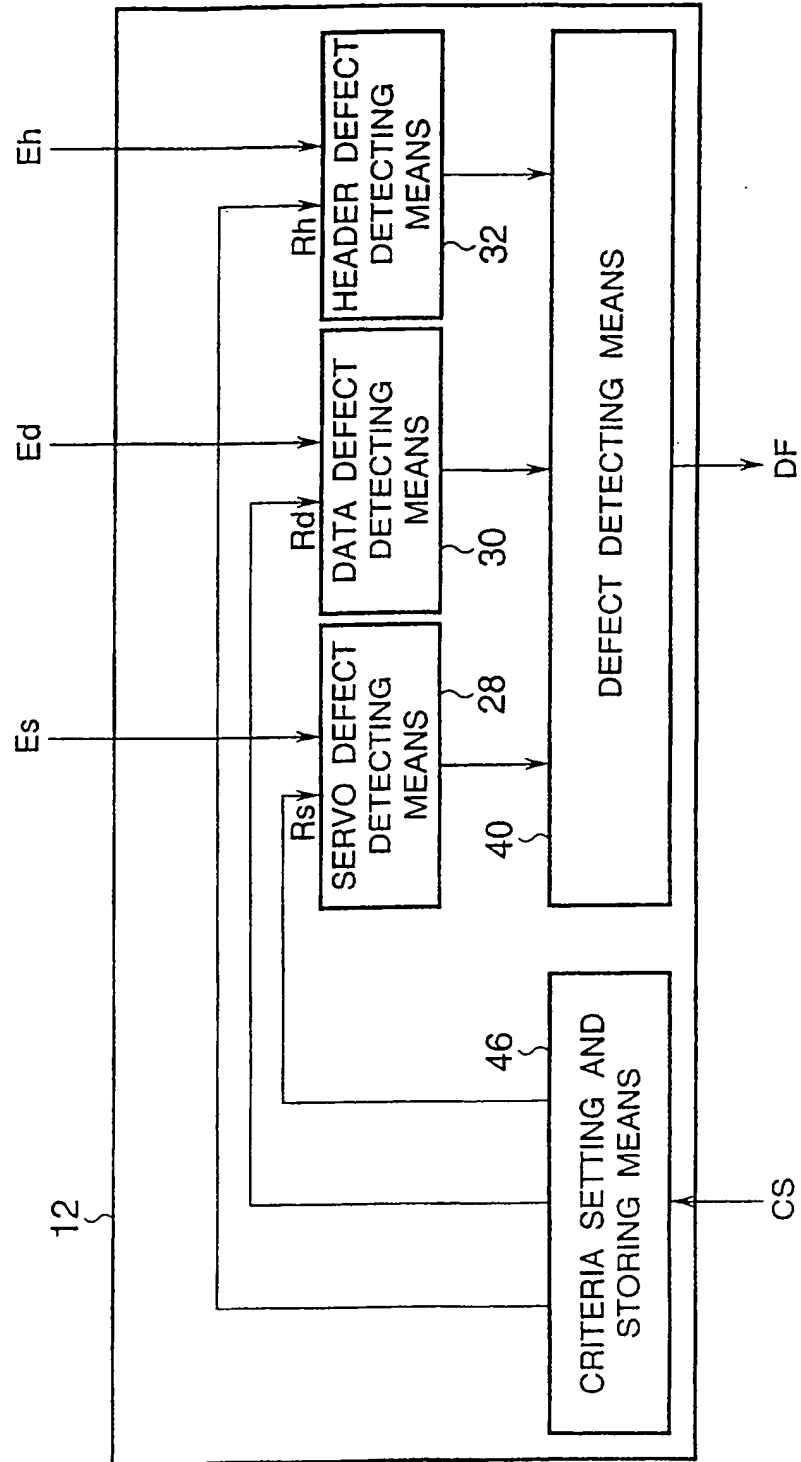


FIG.9

STEP	HOST	INTERFACE	DRIVE
1	DETERMINE APPROPRIATE CRITERIA		
2	SEND CRITERIA SETTING COMMAND	TRANSFER COMMAND (HOST→DRIVE)	RECEIVE CRITERIA SETTING COMMAND
3			STORE CRITERIA
4	PREPARE DATA		
5	SEND WRITE COMMAND	TRANSFER COMMAND AND DATA (HOST→DRIVE)	RECEIVE COMMAND AND DATA
6			RECORD DATA ON OPTICAL DISK
7	RECEIVE RESULT SIGNAL	TRANSFER RESULT SIGNAL (DRIVE→HOST)	SEND RESULT SIGNAL
8	TAKE APPROPRIATE ACTION		

FIG.10

STEP	HOST	INTERFACE	DRIVE
1	DETERMINE APPROPRIATE CRITERIA		
2	PREPARE DATA		
3	SEND COMBINED CRITERIA SETTING AND WRITE COMMAND	TRANSFER COMMAND AND DATA (HOST→DRIVE)	RECEIVE COMMAND AND DATA
4			STORE CRITERIA
5			RECORD DATA ON OPTICAL DISK
6	RECEIVE RESULT SIGNAL	TRANSFER RESULT SIGNAL (DRIVE→HOST)	SEND RESULT SIGNAL
7	TAKE APPROPRIATE ACTION		

FIG.11

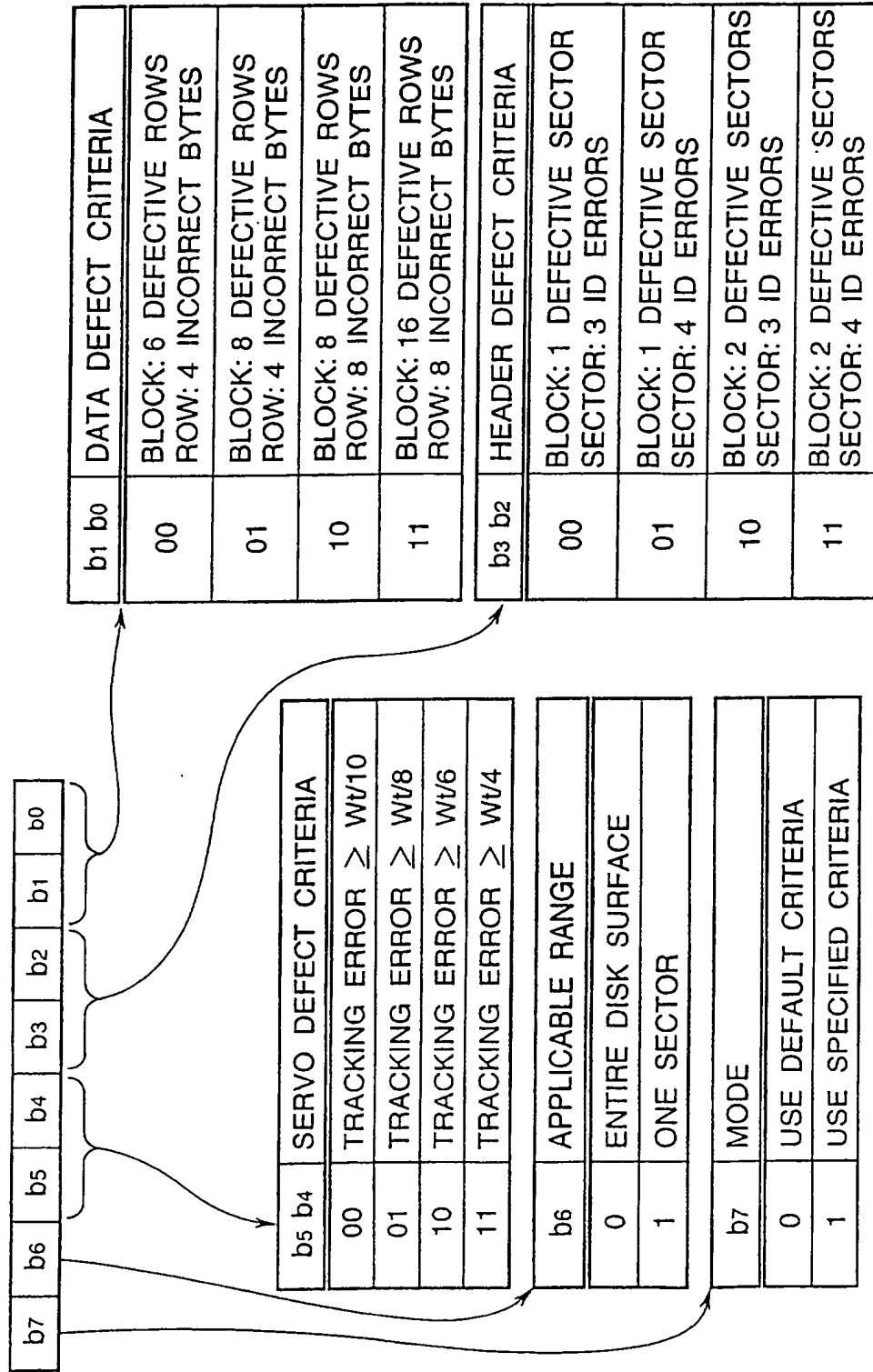
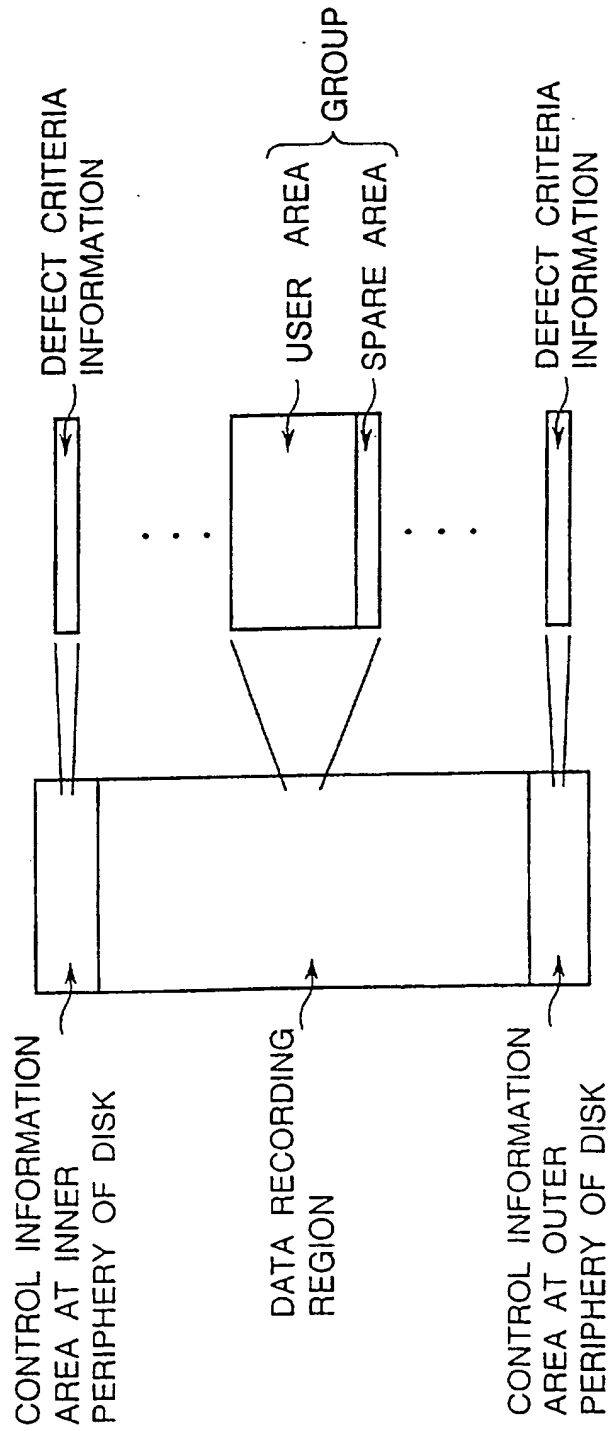


FIG.12



METHOD OF MANAGING DEFECTS IN AN OPTICAL DISK,
AN OPTICAL DISK DEVICE AND AN OPTICAL DISK

BACKGROUND OF THE INVENTION

The present invention relates to a method of managing defects in a disk recording medium, an optical disk device recording data on the optical disk using such a defect management method, and an optical disk capable of storing information concerning a defect criteria used for replacing a defective area of disk with a non-defective area.

A very high degree of reliability less than 10^{-12} at worst is required of a disk used for recording computer data. Defect-managing systems have been used hitherto to accommodate the reality that defects in recording sectors which lead to an error are unavoidable, even very rare, in the current disk-manufacturing technique.

Disk mediums are subjected to the defect management for assuring data reliability even when dirt, scratches or degradation due to repetition of rewriting operation is caused. Primary defects occurring at the time of manufacture of the disks are found through a certifying process carried out at the time of initializing disks, and secondary defects occurring after being put to use are found through verification carried out at the time of writing, or the like. Sectors found to have a defect are replaced, using sectors located in a spare area formed on part of a disk other than a user area. In the defect management, a pair of a user area and a spare area is called a group.

In an example of arrangement of user areas and spare areas on a disk, the data area consists of a single group. However, there are many optical disks in which a data area is divided into a plurality of groups. When a defective group is found in a group, it is first attempted to replace the defective sectors using sectors in a spare area of the

same group. In many cases, an optical disk is configured such that a recording capacity of a spare area is several % of that of a user area. The 90mm magneto-optic disk standard defined by ECMA-154 or ECMA-201, and the DVD-RAM standard defined by ECMA-272 are examples of such configuration.

Incidentally ECMA is an abbreviation of European Computer Manufacturers Association, DVD is an abbreviation of digital video disk, and RAM is an abbreviation of random-access memory.

The presence or absence of a defect in a sector can be determined by an error in an ID signal representing a physical address of the sector, an error in a recorded data signal, or a servo error signal.

When a plurality of ID's are recorded in the header area for each sector, if not less than a predetermined number of ID's for each sector contain an error, the sector in question is found have a header defect. In DVD-RAM standard for example, each sector is provided with four ID's, and an error can be detected for each ID. Each sector is not found to have a header defect it has not more than two ID errors: a sector having three or more ID errors is found to have a header defect, since its reliability is low.

Further, the presence or absence of an error in a recorded data signal is detected by the use of an error correcting code added thereto. When more than a predetermined number of errors are included per unit of recording, the data signal is found to have a data defect. The "unit of recording" may be a sector or a block constituted of a plurality of sectors depending on the span of an error correcting code (ECC).

In the DVD-RAM standard, data is recorded in sectors on a disk, and is subjected to error-correcting coding in units of 16 sectors, called an ECC block. Data of 32 KB

constituting one ECC block is arranged in the form of matrix of 172 x 192 bytes (or 172 columns x 192 rows), and Reed-Solomon codes (inner code PI, outer code PO) of 10 bytes and 16 bytes are added in column direction and row direction, respectively, to constitute a product code.

The inner code PI is disposed so as to be complete within a sector. By means of the inner code PI, the number of error bytes in each row of the reproduced data can be determined. In accordance with the detected number of errors, reliability of each row is evaluated, and whether each sector or each block has a data defect can be determined based on the number. For instance, a sector including four or more rows having four or more error bytes is found to have a data defect, or a block including six or more such rows are found to have a data defect.

With regard to detection of defects based on a servo error signal, when the magnitude of the servo error signal such as a tracking error signal exceeds a predetermined value that makes it difficult to ensure the servo control stability required of data recording, a sector in question is found to have a servo defect.

When a sector is found to have a header defect, a data defect or a servo defect, it is found to be defective.

Generally, in the defect management, two different methods are used for performing replacement of a sector. One is a slip replacement, and the other is a linear replacement.

The slip replacement is applied to primary defects. If a defective sector is found at the time of certifying a disk, the next sector is used in place of the defective sector. In a disk drive device, for accessing a sector containing data, a logical address is converted into a physical address representing the position of the sector, and a sector having ID's representing the physical address

is accessed. When the slip replacement has been performed, the physical address numbers corresponding to the logical addresses are shifted, or "slip" by one.

The slip replacement is carried out within each group. For instance, if there occur two slip replacements of m sectors and n sectors in a user area, the end of the user area of the group is shifted into the head of the spare area by $(m+n)$ sectors. If such slip replacements are made, the linking relation between the physical addresses and logical addresses is shifted by the number of replaced sectors for all the sectors succeeding the replaced sectors. Primary defects subjected to the slip replacement are registered in a PDL (Primary Defect List). The list contains the physical addresses of defective sectors in each entry.

Linking the physical addresses with the logical addresses can be made only when a disk is initialized, and therefore, the slip replacement is applied to primary defects only.

The linear replacement is applied to secondary defects. When a defective sector is found, replacement is effected using spare sectors in a spare area. When an ECC block (formed of 16 sectors) is found to contain a defective sector, the entire ECC block is replaced with 16 sectors in a spare area. There may be a case where a block in a spare area having replaced another block is subsequently replaced with another block. A substitutive sectors are given the same logical addresses as the original sectors.

The linear replacement is effected within the same group first. For instance, when two linear replacements of m blocks and n blocks respectively occur in a user area, m blocks and n blocks at the beginning of the unused part of the spare area are used. It may be so designed that when the spare area of the same group has been used up the spare area in another group is used. Secondary defects subjected

to linear replacement are registered in an SDL (Secondary Defect List). The list contains physical addresses of defective sectors and substitutive sectors in each entry.

When such a linear replacement has been made, every time an access is made using a logical address which designated a substitutive sector, an access to the substitutive sector and subsequent return have to be made. Therefore, the average data transfer rate is substantially lowered when the secondary defects exist.

A set of the defect lists PDL and SDL is stored in a defect management area within a control information area in each of outer and inner periphery parts. They are disposed at a plurality of locations, and they are recorded together with information on the structure of a disk.

Generally, in recording devices, criteria for detecting primary and secondary defects are set in the following way.

A disk is at its best condition when primary defects are detected and registered. The number of defects on the disk increases with time or usage due to scratches and dirt, and resultant degradation. Therefore, the primary defects are detected and replacement is effected by using a criteria which is more strict than that for detecting the secondary defects, so that some additional scratches or dirt will not results in the finding of a defect according to the criteria for detecting the secondary defects.

Although the secondary defects are detected with a criteria which is less strict than that for the primary defects, a margin of safety is left between the criteria for detecting the secondary defects and the error-correcting capability, so as to ensure error correction during reproduction. In this way, different criteria are used for the primary defect detection and the secondary defect detection.

Conventionally, optical disks are used mainly for

∞ computer data^a recording, and therefore, the primary concern was to improve the data reliability, and defect management mainly consisting of replacement using spare sectors has been developed to deal with the defects in the recording sectors causing the errors.

In recent years, with increasing capacity of optical disks, their uses are expanding to the video recording field, such as in DVD.

α Data files for recording computer data (PC files) are expected to be completely error-free, and high reliability is required of recording. In contrast, data files for recording audio or video^o data (AV files) require recording data inputted continuously in real time. In some cases, errors are permissible as long as the disturbance of reproduced images or sounds is not noticed, so that data reliability is not required to be as high as in computer data recording. Instead, non-interruption of recording is important.

That is to say, with regard to storage devices for computer data recording, primary importance is the reliability rather than recording time, while, for storage devices for video recording, primary importance is continuous recording performance. Consequently, in case of using the same type of disk for recording both audio or video data and computer data, it is required to ensure reliability and recording speed which meet the requirements of the respective recordings. Likewise, defect management is required to be adaptable to both types of recording.

Conventional defect management for optical disks has the following drawbacks.

For carrying out replacement to deal with secondary defects of a disk at the time of recording, data is reproduced from the recorded part for verification, and if errors of more than a prescribed criteria, or a defective

part from which reproduction is impossible is found, the data recorded in that part is re-recorded in substitutive sectors in a spare area, and data is again reproduced from the substitutive sectors for verification. Thus, when a secondary defect is detected, and replacement is effected, the time needed is four times more of the time needed for recording data once. In case of recording audio or video data in real time, it is likely that recording is interrupted if a defect is detected.

One solution to this problem is not to detect secondary defects during the recording audio or video data. In this case, the reproduced image or the like may have disturbances at parts having the secondary defects, but they are considered less objectionable than interruption of recording. The underlying assumption is that once primary defects have been removed at the time of initialization of the disk, any secondary defects that might occur will be minor. If the scale of the secondary defects are beyond the prediction, the disturbance of the reproduced picture may be intolerable, and thus this solution fails.

Where the optical disks are used for recording audio or video data, it is considered unnecessary to detect defects with criteria which is as strict as that used in recording computer data. This is because, if the excessively strict criteria is used, sectors which are permissible for audio or video data are also found defective, and video recording is interrupted when the time-consuming replacement is effected. Because the conventional defect management method does not take into consideration the intended use of the optical disk, and the criteria used is of the same level regardless of the intended use of the optical disk, and there was no conception of using the optimum defect detecting method.

SUMMARY OF THE INVENTION

The present invention has been made overcome the above-outlined problem, and its object is to adapt defect management to the type of data recorded on an optical disk, or the intended use of the disk.

Another object is to improve the interchangeability of the optical disk.

A further object is to improve the utility of optical disks for recording audio or video data.

According to a first aspect of the invention, there is provided a method of managing defects on an optical disk used for recording data, comprising the steps of

determining a criteria for detecting said defects according to the type of data for which defects are to be detected; and

detecting said defects using said criteria when data is recorded on or reproduced from said disk.

With the above arrangement, it is possible to use the criteria suitable for the particular type of data for which said defects are to be detected.

Said step of detecting said defects may be performed with regard to data recorded on the disk.

In this case the defects may be detected when the data is recorded on the disk, or when the data is reproduced for verification of the data having been recorded. When the defects are detected when the data is recorded, determination of presence or absence of servo defects and header defects can be made, but determination of presence or absence of data defects cannot be made. When the defects are detected during reproduction for verification, presence of absence of data defects as well as servo defects and header defects can be determined.

Said step of detecting said defects may alternatively be performed when the data is reproduced. In such a case, if defects are detected, the reproduction of the data is re-

tried. Decision on whether the reproduction is to be re-tried is made using different criteria depending on the type of data being reproduced.

The method may further comprise the step of using non-defective areas of the optical disk in place of defective areas of the optical disk.

With the above arrangement, the result of the defect detection can be used in making a decision as to whether the areas found to be defective should be replaced with non-defective areas.

Said step of determining a criteria may include:

providing a plurality of criteria; and

selecting one of said plurality of criteria according to the type of data for which defects are to be detected.

With the above arrangement, the defect criteria can be determined simply by providing a signal which selects one of the plurality of criteria provided in advance, rather than specifying the values forming the criteria.

Said plurality of criteria may include at least a first criteria, and a second criteria, said second criteria being less strict than said first criteria, and said step of selecting may comprise selecting said first criteria when the data for which defects are to be detected is one for which time restriction with regard to data recording or reproduction is less strict, and selecting said second criteria when the data for which defects are to be detected is one for which time restriction with regard to data recording or reproduction is more strict.

An example of the data for which time restriction with regard to data recording or reproduction is less strict is computer data. An example of the data for which time restriction with regard to data recording or reproduction is more strict is audio or video data.

By using a less strict criteria for the audio or video

data, interruption of the audio or video data recording is avoided unless the defect is of such a degree that the resultant disturbance in the sound or picture is intolerable.

The method may further comprise the step of sending control information for specifying said criteria, from means for processing data to be recorded, to means for recording said data.

The above-mentioned means for processing data to be recorded is for example a host device. The above mentioned means for recording the data is for example a disk device.

With the above configuration, the host device can set criteria which is finely optimized for the type of the data to be recorded on the disk.

The data may be recorded in units of recording, and said step of sending control information may send the control information for each each unit of recording.

With the above configuration, it is possible to dynamically set criteria which is finely optimized for each unit of recording (e.g., sector or ECC block), depending on the type of the data to be recorded in each unit of recording. That is, even when different types of data, e.g., audio or video data, and computer data, are both recorded on the same disk, since the host device sends the criteria control information in association with the data to be recorded, and the defect management can be effected using the optimum criteria for the respective data.

Said control information specifying the criteria may select one of a plurality of criteria.

With the above configuration, the amount of control information is small, since it only needs to specify one of the plurality of predetermined criteria, rather than specifying values forming the criteria itself.

Data may be recorded in units of recording, and said

method may further comprise the step of recording control information representing the criteria for each unit of recording, on the optical disk, in association with said each unit of recording.

With the above configuration, the criteria to be used for defect detection for each unit of recording (sector or ECC block) is known by reading the control information, and can be used for performing maintenance of the data recorded on the disk.

According to a second aspect of the invention, there is provided a disk device for accessing data on an optical disk, comprising:

means for determining a criteria for detecting said defects according to the type of data for which defects are to be recorded; and

means for detecting said defects using said criteria when data is recorded on or reproduced from said disk.

With the above arrangement, it is possible to use the criteria suitable for the particular type of data for which defects are to be recorded.

Said detecting means may detect said defects with regard to data recorded on the disk.

In this case the defects may be detected when the data is recorded on the disk, or when the data is reproduced for verification of the data having been recorded. When the defects are detected as the data is recorded, servo defects and header defects can be detected, but data defects cannot be detected. When the defects are detected during reproduction for verification, data defects as well as servo defects and header defects can be detected.

The detecting means may alternatively detect defects when the data is reproduced. In such a case, if defects are detected, the reproduction of the data is re-tried. Decision on whether the reproduction is to be re-tried is

made using different criteria depending on the type of data being reproduced.

Said device may comprise means for managing defects on the optical disk by using non-defective areas of the optical disk in place of defective areas.

With the above arrangement, the result of the defect detection can be used in making a decision as to whether the areas found to be defective should be replaced with non-defective areas.

Said determining means may comprise:

means for storing a plurality of criteria; and

means for selecting one of said plurality of criteria according to the type of data for which defects are to be detected.

With the above arrangement, the defect criteria can be determined simply by applying a signal for selecting one of the plurality of criteria provided in advance, rather than specifying the values forming the criteria.

Said plurality of criteria may include at least a first criteria, and a second criteria, said second criteria being less strict than said first criteria, and said selecting means may select said first criteria when the data for which defects are to be detected is one for which time restriction with regard to data recording or reproduction is less strict, and selects said second criteria when the data for which defects are to be recorded is one for which time restriction with regard to data recording or reproduction is more strict.

An example of the data for which time restriction with regard to data recording or reproduction is less strict is computer data. An example of the data for which time restriction with regard to data recording or reproduction is more strict is audio or video data.

By using a less strict criteria for the audio or video

data, interruption of the audio or video data recording is avoided unless the defect is of such a degree that the resultant sound or picture is intolerable.

Said determining means may determine the criteria according a control signal supplied from outside of the device.

The control signal may be supplied from a host device connected to the disk device.

With the above configuration, the host device can set criteria which is finely optimized for the type or contents of the data for which defects are to be detected.

The device may further comprise means for recording data, in units of recording, on the disk,

wherein

said determining means may determine the criteria for each of said units of recording, and

said recording means may also record criteria control information controlling the criteria for each unit of recording, in association with said each unit of recording.

With the above configuration, the criteria to be used for defect detection for the data of each unit of recording (e.g., sector or ECC block) is known by reading the control information, and can be used for performing maintenance of the data recorded on the disk.

According to a third aspect of the invention, there is provided an optical disk for recording data, comprising an area storing criteria control information specifying criteria to be used for detecting defects for data recorded on or reproduced from the disk.

With the above configuration, the criteria to be used for detecting defects when the disk is accessed is known by reading the criteria control information recorded on the disk. Accordingly, the maintenance of the data on the disk is facilitated, and the interchangeability of the disk is

improved since the criteria control information can be read by any disk device.

Said data may be recorded in units of recording, and said criteria control information indicating the criteria to be used for detecting detect with regard to said each unit of recording may be recorded in association with said each unit of recording.

With the above configuration, the criteria to be used for each unit of recording, e.g., sector or ECC block, is known by reading the criteria control information, and can be used for performing maintenance of the data recorded on the disk.

Said information may select said criteria from a plurality of predetermined criteria.

With this configuration, the amount of control information is small, since it only needs to specify one of the plurality of predetermined criteria, rather than specifying values forming the criteria itself.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:-

Fig. 1 is a block diagram of an optical disk device of an embodiment of the present invention;

Fig. 2 is a block diagram of a defect determining means used in the optical disk device of Fig. 1;

Fig. 3A is a schematic diagram showing examples of deformation of a groove forming a track;

Fig. 3B is a time chart showing a tracking signal obtained when the light spot follows the track shown in Fig. 3A;

Fig. 4A is a diagram showing the configuration of a sector on a DVD-RAM;

Fig. 4B is a schematic diagram showing the signal obtained when the light spot follows the sector shown in

Fig. 4A;

Fig. 5 is a diagram showing an example of errors in an error correcting block;

Fig. 6 is a table summarizing two sets of defect criteria;

Fig. 7 is a table summarizing three sets of defect criteria;

Fig. 8 is a block diagram of a defect determining means of another embodiment;

Fig. 9 is a diagram showing an example of procedure followed for setting defect criteria;

Fig. 10 is a diagram showing another example of procedure followed for setting defect criteria;

Fig. 11 is a diagram showing the configuration of an example of defect criteria control information; and

Fig. 12 is a view showing arrangement of information for controlling defect criteria on an optical disk.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Embodiments of the invention will now be described with reference to the attached drawings, in which like parts are indicated by like reference characters.

Fig. 1 is a block diagram of an optical disk device used to implement the defect management method according to the invention. A disk rotating means 4 controls rotation of an optical disk 2 for recording and reproducing data. An optical head servo means 22 performs position control over an optical head 6 such that a light spot formed by a light beam focused by the optical head 6 follows the track on the disk 2.

The light reflected from the optical disk 2 representing the data recorded on the disk 2 is converted in the optical head 6 into an electrical signal, which is supplied to an address reproducing means 8 and a signal

reproducing means 10. Based on an ID signal in the header, the address reproducing means 8 reproduces the address of a sector currently accessed. The detected address is sent to a drive control means 14. The signal reproducing means 10 reproduces signals from the signals supplied from the optical head 6 in accordance with the recording format. A data reproducing means 16 corrects errors in the reproduced signals to produce information, and outputs information to a host device (not shown) as reproduced data of the desired logical block.

At that moment, the data reproducing means 16 can recognize a sector in which the required data is recorded on the basis of control signals received from the drive control means 14. Concurrently, the drive control means 14 sends a command to control the rotational speed of the disk 2, to the disk rotating means 4. Further, the drive control means 14 determines the position on the disk, of the sector containing the information to be reproduced, and sends commands to the optical head access means 20 for moving the optical head 6 to the position of the sector. The drive control means 14 also sends commands to control the operation of the servo system. The optical head access means 20 and the optical head servo means 22 control the position of the optical head 6 in accordance with the received commands.

A defect management control information detecting means 18 reads control information necessary for performing defect management, from the reproduced data, and obtains information concerning defect management such as defect management method applied to the disk, arrangement of spare areas and user areas, status of use of substitutive sectors, and defect criteria. The information thus obtained is sent to the drive control means 14 and used for controlling devices engaged in defect management at the time of

recording or reproducing data.

Incidentally, all the sectors on the disk are numbered with consecutive addresses from the inner or outer periphery of the disk. However, the addresses of user data recording sectors are not consecutive. This is because the physical addresses are assigned not only to the user data recording sectors, but also to sectors in spare areas provided for defect replacement and sectors in guard areas at zone boundaries in the case of a zone format disk.

At the time of performing access from the host device through an interface, logical block numbers of a file system are used. Therefore, the disk device needs to perform conversion between a logical block number and a sector address. The conversion is carried out by the drive control means 14 in accordance with received information on defect management.

In writing operation, data sent from the host device is first inputted to a data recording means 24. The data recording means 24 performs error correction coding on the data in accordance with a format, and outputs the data as signals to be recorded, with timings controlled in accordance with the sector addresses on the disk, having been detected by the control signals supplied from the drive control means 14.

A signal recording means 26 modulates the received signals in accordance with a recording format and sends them to the optical head 6.

The optical head 6 writes the signals into the optical disk 2 by driving a laser.

At this moment, the optical head 6 is controlled such that a light spot traces the sector the data is to be recorded, by means of the optical head access means 20 and the optical head servo means 22.

The drive control means 14 stores defect management

control information detected by the defect management control information detecting means 18 at the time of disk loading. The logical block number of the block to be accessed is given by an interface control signal supplied from the host device, not shown. To be more specific, the host device sends a recording command specifying the logical block number of the block where the data is to be written, and the like, to the disk device, together with the data to be recorded, or sends a reproducing command specifying the logical block number of the block from which the data is to be read and the like, to the disk device.

The drive control means 14 converts the logical block number of the block to be accessed, to physical addresses, using defect management information, and sends a command specifying the physical addresses of the sectors to be accessed, to the optical head access means 20 and data recording means 24 or data reproducing means 16. The physical addresses of the sectors currently accessed are reproduced by the address reproducing means 8, and inputted to the drive control means 14. Drive control operations such as control over the optical head access means 20 and data recording means 24 or data reproducing means 16 are performed on the basis of the detected current address and the target address.

A defect determining means 12 makes judgment as to whether a sector is defective and is to be replaced. The defect determining means 12 receives information necessary for defect determination on each sector from the optical head servo means 22, address reproducing means 8, and data reproducing means 16, and determines presence or absence of a defect in accordance with a defect criteria set by the drive control means 14, and reports the results of the determination to the drive control means 14. When the sector having been accessed is determined as a defective

sector, the drive control means 14 performs the necessary processes. During recording, the drive control means 14 interrupts the recording operation and causes the data of the block to be re-recorded in substitutive sectors. During verifying reproduction, the drive control means 14 causes the data of the block having been recorded, to be re-recorded in substitutive sectors. During reproduction, the drive control means 14 causes the reproduction to be re-tried. These operations are pre-programmed into the drive control means 14.

Fig. 2 shows the configuration of the defect determining means 12. It receives servo error signals such as a tracking error signal and a focus error signal from the optical head servo means 22. It also receives a header error signal representing the number of errors in ID's reproduced for each sector, from the address reproducing means 8. It also receives a data error signal representing the number of errors in the reproduced data from the data reproducing means 16.

In this embodiment, the defect determining means 12 includes two defect criteria storing means 34 and 36 for storing different defect criteria A and B, respectively. The two defect criteria A and B are inputted to a defect criteria selecting means 38, which selects and outputs either one of the two criteria A and B in accordance with a defect criteria setting signal CS. There are three outputs, Rs, Rd, and Rh. A reference signal Rs for detecting a servo defect is inputted to a servo defect detecting means 28, a reference signal Rh for detecting a header defect is inputted to a header defect detecting means 32, and a reference signal Rd for detecting a data defect is inputted to a data defect detecting means 30. They are compared with a servo error signal Es, a header error signal Eh, and a data error signal Ed in the respective defect detecting

means 28, 32 and 30, to detect presence or absence of a servo defect, a header defect, and a data defect. A defect detecting means 40 receives the outputs of the defect detecting means 28, 32 and 30, and outputs a defect detection signal DF when at least one of the defects has been detected.

Referring to Fig. 3A and Fig. 3B, detection of a servo defect will be described. For recording data, a track which has a substantially uniform width W_t (the track is actually circular or spiral, but the short part of the track illustrated can be treated as straight) is used. The track is formed of a continuous guide groove or the like. Consideration will be given to the case where the track is deformed at points X and Y. Such deformation may be caused due to dirt introduced during fabrication of a master disk or a substrate, irregular operation of a manufacturing machine, unevenness of a formed substrate, and other minor irregularities. Tracking control is performed such that a light spot follows the centerline 42c of the track shown by a chain line in Fig. 3A, and a tracking error signal E_t shown in Fig. 3B is obtained. The tracking error signal E_t is zero when the light spot is following the centerline 42c of the track. When the light spot deviates from the centerline 42c, the tracking error signal E_t deflects either positively or negatively depending on the direction and the amount of deviation. Where there is a deformation of the track and the centerline 42c of the track is bent abruptly, since the light spot cannot follow the abrupt bending, the light spot deviates from the centerline 42c.

At point X, there is a deflection in the tracking error signal E_t due to the deformation of the track. At point Y, there is also a deflection in the tracking error signal E_t due to meander of the track. If the tracking error tolerance limit R_{tb} shown by the broken line in Fig. 3B is

given as a reference for determining a servo defect, a servo defect is recognized at point Y. If a more strict tracking error tolerance limit R_{ta} shown by the chain line in the figure is given, servo defects are recognized both at points X and Y.

The tracking error tolerance limit R_{ta} corresponds to the value of the tracking signal E_t when the deviation of the light spot is one-fourth the tracking width W_t , and the tracking error tolerance limit R_{tb} corresponds to the value of the tracking signal E_t when the deviation of the light spot is one-eighth the tracking width W_t .

For instance, if the level R_{ta} at the chain line is used as the defect criteria A, and the level R_{tb} at the broken line the figure is given as the defect criteria B, it is possible to perform servo defect determining process at two different levels. Incidentally, the recording track may not be a continuous groove. In a disk, such as a DVD-RAM, where user data recording areas are formed of lands and grooves, and no groove is formed at the header parts, which are formed of pre-pits only, it is sufficient to perform a servo defect detection only for areas where a groove continues.

Servo defect detection can be performed with regard to a focus error signal, in the same way as the tracking error signal.

Fig. 4A shows the configuration of a sector in a groove track in a DVD-RAM, and Fig. 4B shows the waveform of the signal reproduced from the sector shown in Fig. 4A. These drawings will be used for describing the detection of header defect. A recording sector of a DVD-RAM includes a header area having a sector address and the like at the beginning, followed by a data area for recording user data. The header area includes four ID's, indicated as ID1 to ID4 each containing address information representing a sector

address. In the sector shown in Fig. 4A, ID1 and ID2 are displaced one-half the track width W_t toward the outer periphery of the disk, and are shared with a sector in the outer adjacent land track, while ID3 and ID4 are displaced one-half the track width W_t toward the inner periphery of the disk, and are shared with a sector in the inner adjacent land track.

In a land track not shown, ID1 and ID2 are displaced by one-half the track width W_t toward the inner periphery of the disk, and are shared with a sector in the inner adjacent groove track, and ID3 and ID4 are displaced by one-half the track width W_t toward the outer periphery of the disk, and are shared with a sector in the outer adjacent groove track. The waveform of the signal reproduced from the header area and the data area in a sector in a land track is also shown in Fig. 4B.

The data area following the header is in a groove or a land, and contains a synchronous signal (SYNC), control information (CI), user data, and an error-correcting codes, and a buffer, which are recorded successively in this order. The control information CI consists of a small amount of information (such as the data number of the sector), other than user data.

The size of user data, together with the control information, in one sector is 2 KB (kilobytes), and error-correcting coding is performed taking the user data and the control information of 32 KB in 16 successive sectors, as a unit, wherein error-correcting codes are added to the to form an ECC block.

The error-correcting codes are distributed over the 16 sectors.

The sector address can be obtained if even one of the four ID's in a header is read correctly. In criteria B, if none of the four ID's is read correctly, the sector is found

have a header defect, and if two or more sectors within an ECC block are found to have a header defect, the ECC block is found to have a header defect. In criteria A, if not more than one of the four ID's is read correctly, the sector is found have a header defect, and if one or more sectors within an ECC block are found to have a header defect, the ECC block is found to have a header defect.

A sector found to be non-defective according to criteria A has at least two correctly readable ID's. This make it more likely that at least one ID will remain correctly readable even if the disk is later soiled or degraded, or transferred to another disk device.

In this way, it is possible to perform header defect determination with two different levels.

Fig. 5 shows the structure of an ECC block in a DVD-RAM. This drawing is used to describe the data defect detection. In the data recording means 24, the 23 KB data for 16 sectors are arranged in the form of matrix of 172 bytes in the row direction by 192 bytes in the column direction. A 16-byte parity outer code P0 in the column direction is added to each column, and then 10-byte parity inner code PI in the row direction is added to each row.

Thus, a product code, which is a Reed-Solomon code, of 182 bytes x 208 bytes is formed.

When the data is recorded on the optical disk 2, the P0 rows are interleaved with the other rows so that the error-correcting code bytes are evenly distributed over all 16 sectors of the ECC block.

At the time of reproduction, the data reproducing means 16 rearranges the reproduced signal into a matrix of 182 bytes x 208 bytes, and first detect and correct any errors of each row by means of the 10-byte inner code PI. The inner code PI is capable of correcting errors in up to five bytes per row, and detecting errors in up to ten bytes per

row.

Next the 16-byte outer code P0 is used to detect and correct any remaining errors. The outer code P0 is capable of correcting errors in up to 8 bytes per column, and detecting errors in up to 16 bytes per column. These error detecting and correcting capabilities can be improved by repeating the PI-P0 error correction process, although the additional repetitions require additional circuitry and additional time.

When a large number of errors are detected and corrected, it becomes likely that some of the corrections are wrong, the corrected data differing from the original data. Criteria A and B are therefore set, for example, as follows. In criteria A, a row is considered to have a data defect if errors are detected in at least four bytes, which is close to the error-correcting limit of the PI code, and an ECC block is considered to have a data defect if it has at least eight rows having a data defect. In less strict criteria B, a row is considered to have a data defect if errors are detected in at least eight bytes, which is close to the repeated error-correcting limit of the PI code, and an ECC block is considered defective if it has at least eight rows having a data defect. When an ECC block is considered to have a data defect, all sixteen of its constituent sectors are replaced.

In this way, it is possible to perform data defect determination with two different levels.

In FIG. 5, row three has errors in four bytes, indicated by x's. This row is deemed to have a data defect under criteria A, but not under criteria B.

In this way, the presence or absence of defect in each sector can be determined with respect to each of the servo defect, the header defect, and the data defect, according to the defect criteria supplied to each defect detecting means.

Fig. 6 summarizes the defect criteria A and B described above described as examples for the respective defects. The set of criteria A are stored in the criteria storing means 34, while the set of criteria B are stored in the criteria storing means 36. It is then possible to switch between the two levels of criteria A and B by means of the criteria selecting means 38, according to the criteria setting signal CS.

In the case of recording computer data, a high reliability is required so that the data once recorded are not lost or changed. For this reason, verifying reproduction is often effected at the time of recording. Accordingly, during recording and during verification production, the strict criteria A is applied to ensure that the correct data is recorded.

In contrast, in the case of audio or video data, continuous recording at a high transfer rate is required. Accordingly, verifying reproduction is often omitted, ignoring data defects. Even if some defects occur during recording, as long as occurrence of the defects is of such a degree that the defects can be corrected or concealed later at the time of reproduction, it is preferable to continue recording operation ignoring the defects, since it will improve the performance and the operability as a recorder. For this reason, the criteria set for servo defects and header defects are set at a less strict level at which the recorded data can be corrected or concealed.

When the two different defect criteria A and B available, the strict criteria A is used for recording computer data, while the less strict criteria B is used for recording audio or video data.

There are situations where more than two different levels of reliability are required depending on types of

data to be recorded. For instance, there is a situation where three different levels are required, one for recording computer data, another for recording important audio or video data, and the last one for recording normal audio or video data. In such a situation, as shown in Fig. 7, provision is made to enable switching among three different defect criteria A, B, and C. Criteria A and B are the same as those described with reference to Fig. 6, and are used for recording computer data and for recording normal audio or video data, respectively.

The criteria C is used for recording important audio or video data, and therefore, it has strictness intermediate between the criteria A and B. In the criteria C, the allowable deviation in tracking error is one-sixth the track width W_t , and an ECC block is found to have a header defect if all four ID's are unreadable in any one sector. Regarding data defects, criteria C and A are the same.

To use the three different sets of defect criteria, the defect determining means 12 should have an additional criteria storing means, in addition to the members shown in Fig. 2, and the criteria selecting means 38 should be able to select among the criteria A, B and C supplied from the above-mentioned additional criteria storing means, as well as the criteria storing means 34 and 36 in Fig. 2, in accordance with the criteria setting signal CS.

Fig. 8 shows another embodiment of the defect determining means 12. The configuration of Fig. 8 is different from the configuration of Fig. 2 in that the criteria storing means 34 and 36, and the criteria selecting means 38 which makes selection according to the criteria selecting signal CS shown in Fig. 2 are replaced with a defect setting and storing means 46 which makes setting according to the criteria selecting signal CS.

The defect criteria to be applied is supplied from a

host device (not shown) through an interface to the drive control means 14. In response, the drive control means 14 generates a criteria setting signal CS specifying the criteria.

In the defect determining means 12 of Fig. 2, the defect criteria stored in the respective criteria storing means are fixed. However, in practical use, it may be desirable that the host device which controls the disk device (recording device) can flexibly vary the criteria so as to optimize the reliability and the transfer rate, depending on the nature, type, characteristics, and the degree of importance of the data to be recorded. For instance, a countermeasure for errors may be provided in the application software or file system. That is, error correcting coding may be applied before transmitting the data to the disk device at a predetermined rate. In this case, the defect management at the disk device is not so important, and the capability of continuous real-time recording at a high data transfer rate may be important.

The embodiment described above can meet with these requirements.

An embodiment of procedure followed in setting a defect criteria will be described with reference to Fig. 9. First, the host device sets the defect criteria to be used, according to type or contents of the data to be recorded. Then, a command for setting the criteria is sent from the host device to the disk device (drive). The disk device selects or sets the criteria upon reception of the command accordingly. In the system shown in Fig. 2, the command sent from the host device to the disk device is one for merely specifying selection between the criteria A and B. In the system shown in Fig. 8 in which the defect criteria can be set, the system is so configured that the defect criteria can be set arbitrarily at the host device, and the

command indicates the defect criteria set at the host device. Details of the command for setting the defect criteria may be one which will be described later with reference to Fig. 11, in which the defect criteria control information can select one among a plurality of criteria independently, for each of the servo defect, header defect, and data defect.

The host device then sends a recording command together with the data to be recorded. Upon reception of the command, the disk device records data in the specified sectors, and performs the defect management using the defect criteria set in the manner described above, and reports the results of the defect management to the host device. The host device terminates a series of recording when it confirms that recording has been completed correctly. If the recording has been done incorrectly, a predetermined process (re-writing or informing the user) for dealing with the incorrectness is carried out.

According to the procedure of Fig. 9, the host device, which knows the contents of the data to be recorded, sets the defect criteria finely optimized according to the type or contents of the data. It is therefore possible to provide flexibility for obtaining an optimum combination of reliability and transfer rate according to the intended use of the data.

Fig. 10 shows another embodiment of a procedure followed for setting a defect criteria. In this embodiment, a command which sets a defect criteria and also instructs data recording is sent. First, the host device determines a defect criteria to be used in accordance with the type or contents of the data to be recorded, and then prepares the data to be recorded. This order may be reversed.

Then, the host device sends the recording command which also sets the defect criteria, to the disk device. In

accordance with the designated defect criteria, the disk device selects or sets the criteria. The designation of the setting sent from the host device to the disk device may be one for specifying selection among a plurality of preset criteria (such as between the criteria A and B), or one for setting an arbitrary criteria.

The disk device records the data received together with the command, on the disk, while performing defect management in accordance with the defect criteria which has been set as described above, and informs the host device of the result. According to this embodiment, it is possible to obtain an optimum combination of reliability and transfer rate depending on the intended use of the disk, as in other embodiments described earlier. Moreover, because the number of commands transferred is reduced, the overhead is reduced, and the possibility of the transfer rate becoming lowered is reduced.

A manner of recording control information representing the defect criteria designated at the time of data recording, in every sector on a disk will now be described. Fig. 11 shows the configuration of a defect criteria control information. With this configuration, one of four different criteria can be specified for each of the servo defect, the header defect and the data defect independently, by using one byte.

The most-significant bit b7 indicates the mode of designation of the defect criteria. If the value of bit b7 is "1", the mode designated by other bits of the control information byte is used, while if the value is "0" the default criteria which the disk device has is used ignoring the other bits of the control information byte.

The next bit b6 indicates the range within which the defect criteria should be applied. If the value of bit b6 is "1", the mode set by other bits in the control

information byte of are applied for each unit of recording, e.g., each sector or block. If the value of bit b6 is "0" the same criteria is to be applied over the entire surface of the disk.

The next two bits (b5 and b4) indicate the criteria applied for the servo defect, among the four criteria. If the combined value of bits b5 and b4 are "11" the tracking error tolerance above which the servo defect is recognized is one-fourth the track width W_t . If the combined value is "10" the tolerance is one-sixth the track width W_t . If the combined value is "01" the tolerance is one-eighth the track width W_t . If the combined value is "00" the tolerance is one-tenth the track width W_t .

The next two bits b3 and b2 indicate the defect criteria to be applied for the header defect, among the four criteria. If the combined value of the bits b3 and b2 is "11" the ECC block is found to have a header defect if all four ID's are unreadable at two or more of its sectors. If the combined value is "10" the ECC block is found to have a header defect if three or more ID's are unreadable at two or more of its sectors. If the combined value is "01" the ECC block is found to have a header defect if all four ID's are unreadable at one or more of its sectors. If the combined value is "00" the ECC block is found to have a header defect if three or more ID's are unreadable at one or more of its sectors.

The last two bits b1 and b0 indicate the defect criteria to be applied for the data defect, among the four criteria. If the combined value of the bits b1 and b0 is "11", the ECC block is found to have a data defect if at least 16 of its rows have errors in at least 8 bytes each. If the combined value is "10", the ECC block is found to have a data defect if at least 8 of its rows have errors in at least 8 bytes each. If the combined value is "01", the

ECC block is found to have a data defect if at least 8 of its rows have errors in at least 4 bytes each. If the combined value "00", the ECC block is found to have a data defect if at least 6 of its rows have errors in at least 4 bytes each.

The above described defect criteria control information can be located in each sector which constitutes a minimum unit of recording. In a DVD-RAM, a one-byte area may be reserved in the control information area located at the beginning of the data area shown in Fig. 4. The criteria may be set for each sector separately. The same defect criteria control information may be set in all the sectors within the same ECC block, or in predetermined sectors, so that the defect criteria control information is repeatedly recorded, and the range within which the same defect criteria should be applied may be made to coincide with the unit of error correction (ECC block).

The provision for enabling setting the finely optimized criteria improves the utility for the user in multimedia applications in which the audio or video data and computer data are intermixed with each other. It should be noted that the defect criteria to be applied to the respective data can be switched at the system (host device) depending on the contents of the data, and it is possible to realize a flexibility for obtaining the optimum combination of the reliability and transfer rate.

It is possible to pre-select a defect criteria to be used in recording on a disk, and record the criteria as defect criteria control information on the disk, before the disk is used. Fig. 12 shows an example of arrangement of control information areas, and a data recording region including user areas and spare areas, and arrangement of defect criteria control information in the control areas. The data recording region is divided into groups, each of

which includes a user area and a spare area. The control information areas are disposed near the inner and outer peripheries of the disk, and the same control information is recorded on the respective control information areas.

In a known example, a defect management method is recorded in a control information area. In contrast, according to this embodiment, defect criteria control information is stored in a control information area. At the time of starting a disk, the disk device reads the defect criteria control information to know the defect criteria. If the defect criteria suitable for the intended use, such as computer data, audio or video data, or the like is recorded, the defect determination according to the defect criteria can be made.

If one bit is provided in the control information area for recording the defect criteria control information, it is possible to record two sets of defect criteria, and selectively use them. For recording three or four sets of defect criteria, and using them selectively, two bits should be provided in the control information area. If one byte is provided in the control information area, it is possible to select one of the criteria for each of the servo defect, data defect and header defect, and to specify a combination of specific defect criteria for the respective types, as described with reference to Fig. 11.

With such a provision, if the information is recorded once at the time of initialization of the disk, the defect criteria can be applied to all the data thereafter recorded on the disk. It is therefore possible to eliminate the need to set the defect criteria each time the data is recorded. Accordingly, the recording can be effected at a high speed, and in a simple manner.

CLAIMS:

1. A recording device controller comprising:
means for determining defect detection criteria applied according to
5 the type of data to be recorded; and
means for issuing a command for setting the determined defect
detection criteria in a recording device.
2. A recording device controller comprising:
10 means for determining defect detection criteria applied according to
the type of data to be recorded; and
means for issuing a single command for instructing that the
determined defect detection criteria be set in a recording device and that
recording of data be carried out.
- 15 3. The controller according to claim 1 or claim 2, wherein said command
is of a structure by which the defect detection criteria can be designated
independently for a plurality of kinds of criteria items.
- 20 4. A recording device controller comprising:
means for determining information relating to the type of data
recorded in accordance with the type of data recorded; and
means for issuing a command for transferring the information relating
to the type of data recorded that has been determined to a recording device.
- 25 5. A recording device controller comprising:
means for determining information relating to the type of data
recorded in accordance with the type of data recorded; and
means for issuing a single command instructing that the information
30 relating to the type of data recorded that has been determined be transferred to
a recording device, and that the recording of the data be carried out.

6. The controller according to claim 4 or claim 5, wherein the information relating to the type of data recorded is a flag designating a method of defect processing for the data recorded.

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7. A method of managing defects on an optical disk used for recording data, comprising the steps of

determining a criteria for detecting said defects according to the type of data for which defects are to be detected; and

10 detecting said defects using said criteria when data is recorded on or reproduced from said disk.

8. A disk device for accessing data on an optical disk, comprising:

15 means for determining a criteria for detecting said defects according to the type of data for which defects are to be recorded; and

means for detecting said defects using said criteria when data is recorded on or reproduced from said disk.

9. An optical disk for recording data, comprising an area storing criteria control information specifying criteria to be used for detecting defects for data recorded on or reproduced from the disk.

20 10. A disk recording and/or reproducing device comprising means for applying one of a plurality of predetermined criteria for recording and/or reproducing data according to the type of data to be recorded and/or reproduced.

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CLAIMS:

1. A disk recording device controller comprising:
means for determining defect detection criteria applied according to
5 the type of data to be recorded; and
means for issuing a command for setting the determined defect
detection criteria in a recording device.
2. A disk recording device controller comprising:
10 means for determining defect detection criteria applied according to
the type of data to be recorded; and
means for issuing a single command for instructing that the
determined defect detection criteria be set in a recording device and that
recording of data be carried out.
- 15 3. The controller according to claim 1 or claim 2, wherein said command
is of a structure by which the defect detection criteria can be designated
independently for a plurality of kinds of criteria items.
- 20 4. A disk recording device controller comprising:
means for determining information relating to the type of data
recorded in accordance with the type of data recorded; and
means for issuing a command for transferring the information relating
to the type of data recorded that has been determined to a recording device to
25 determine defect detection criteria.
5. A disk recording device controller comprising:
means for determining information relating to the type of data
recorded in accordance with the type of data recorded; and
30 means for issuing a single command instructing that the information
relating to the type of data recorded that has been determined be transferred to

a recording device to determine defect detection criteria, and that the recording of the data be carried out.

5 6. The controller according to claim 4 or claim 5, wherein the information relating to the type of data recorded is a flag designating a method of defect processing for the data recorded.

7. A method of managing defects on an optical disk used for recording data, comprising the steps of
10 determining a criteria for detecting said defects according to the type of data for which defects are to be detected; and
 detecting said defects using said criteria when data is recorded on or reproduced from said disk.

15 8. A disk device for accessing data on an optical disk, comprising:
 means for determining a criteria for detecting said defects according to the type of data for which defects are to be recorded; and
 means for detecting said defects using said criteria when data is recorded on or reproduced from said disk.

20 9. An optical disk for recording data, comprising an area storing criteria control information specifying criteria to be used for detecting defects for data recorded on or reproduced from the disk.

25 10. A disk recording and/or reproducing device comprising means for applying one of a plurality of predetermined criteria for recording and/or reproducing data according to the type of data to be recorded and/or reproduced.



INVESTOR IN PEOPLE

Application No: GB 0025335.1
Claims searched: All

37

Examiner: Donal Grace
Date of search: 22 March 2001

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK Cl (Ed.S): G5R (RB27, RB33)
Int Cl (Ed.7): G11B 20/12, 20/18
Other: Online: EPODOC; JAPIO; WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X	US 5237553 (FUKUSHIMA et al) see column 4 lines 19 to 49	9

X Document indicating lack of novelty or inventive step
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